

# Flood Information Tool MR3 User Manual



Developed for:

**NATIONAL INSTITUTE OF BUILDING  
SCIENCES**

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The FIT operates as an extension to ESRI's Geographic Information Systems (GIS) software package ArcGIS. The FIT user is subject to ESRI's ArcGIS' license and copyright agreements.

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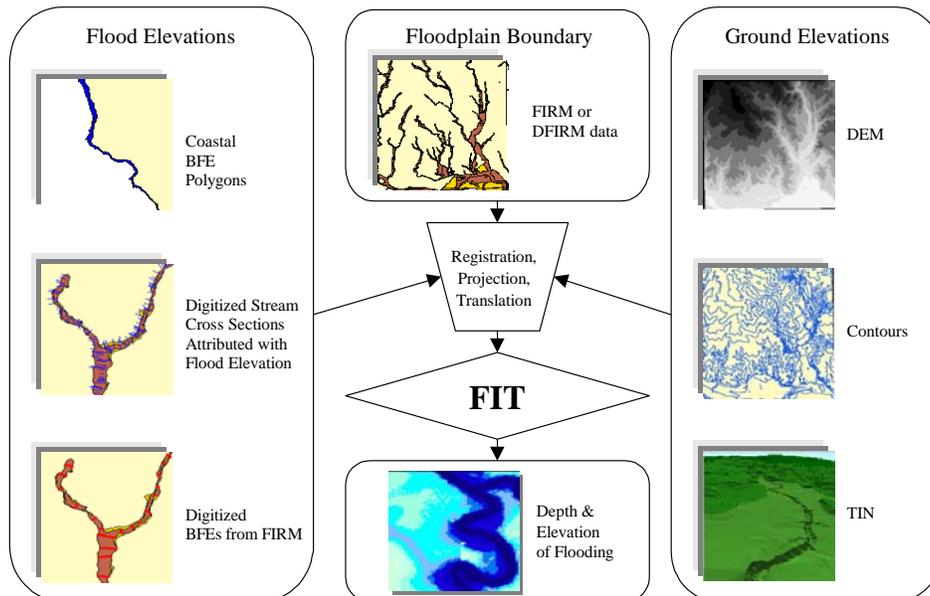
# 1 Introduction

The Federal Emergency Management Agency (FEMA), under a cooperative agreement with the National Institute of Building Sciences (NIBS), has developed a standardized, nationally-applicable natural hazards loss estimation methodology. This methodology is implemented through PC-based geographic information system (GIS) software called *HAZUS-MH*. *HAZUS-MH* applies a multi-hazard methodology, with models for estimating potential losses from earthquake, flood (riverine and coastal), and wind (hurricanes) hazards.

The flood loss estimation methodology consists of two basic analytical processes: flood hazard analysis and flood loss estimation analysis. Flood hazards in the FIT are divided into riverine and coastal. In the riverine hazard module, characteristics such as frequency, discharge, and terrain elevation are used to model the spatial variation in flood elevation and flood depth. In the coastal hazard module, characteristics such as frequency, stillwater elevations, wave conditions, and terrain information are used to model the spatial variation in flood-induced erosion, flood elevation, and flood depth.

The **Flood Information Tool (FIT)** is an ArcGIS extension designed to process user-supplied flood hazard data into the format required by the *HAZUS-MH Flood Model*. The **FIT**, when given user-supplied inputs (e.g., ground elevations, flood elevations, and floodplain boundary information), computes the extent, depth and elevation of flooding for riverine and coastal hazards.

An overall schematic of the **FIT** is provided in Figure 1-1 showing some of the types of data input that users may have and the **FIT** output (depth of flooding).



**Figure 1-1: FIT Schematic**

See Appendix A for information regarding conversion methods for the various types of input data.

The **FIT** stores data in a format and file structure (Appendix B) readily accessible by the *HAZUS-MH Flood Model*. Use of the **FIT** ensures the projection and map units of the data meet the *HAZUS-MH Flood Model* requirements and allows the user to import the data without additional manipulation.

## 1.1 Overview of Requirements

The **FIT** is an ArcGIS extension that provides users with a system of analysis utilities and tutorials used to process user-supplied flood hazard data into the format required by the *HAZUS-MH Flood Model*. The **FIT** is designed for users with GIS experience. Specifically, familiarity with ArcGIS is advantageous. Users should also have an understanding of riverine and/or coastal flooding mechanisms in order to properly create and interpret **FIT** output data.

### 1.1.1 System Requirements

Table 1.1 Hardware and Software Requirements for HAZUS provides guidance for three software operation levels. System requirements are directly related to the volume of data to be used in the analysis. For example, reasonable processing times can be expected when using the “Recommended” computer system if the software operator is analyzing multiple earthquake scenarios for large cities (population > 500,000). The operator is assumed to be working on an Intel PC.

**Table 1-1:**  
**Hardware and Software Requirements for HAZUS**

	Minimal	Moderate	Recommended
Computer Speed Memory	Pentium <sup>®</sup> III 1 GHz core speed and  512 MB RAM  Note: Allows moderately fast analysis of small communities only	Pentium <sup>®</sup> 4 2 GHz core speed and  512 MB RAM  Note: Allows fast analysis of medium- sized communities and real-time analysis for small communities	Pentium <sup>®</sup> 4 with 800 MHz system bus and 2.6 GHz (or better) core speed and 1 GB RAM  Note: Allows fast analysis of large urban areas and real-time analysis for all communities
Computer Storage: Free Hard Disk Space	10 GB  Note: Allows installation of <b>HAZUS</b> and storage of three scenarios for a medium-sized community	40 GB  Note: Allows installation of <b>HAZUS</b> and storage of three scenarios for large urban areas	80 GB  Note: Allows installation of <b>HAZUS</b> and storage of 25 or more scenarios for large urban areas

	Minimal	Moderate	Recommended
Hardware Accessories	CD-ROM reader with 32x minimum read speed DVD-ROM reader with 12x minimum read speed  Graphics Card with 800x600 minimum resolution  Mouse, Keyboard and 19" Monitor		
Supporting Software	Microsoft Windows 2000 SP2 SP3 and SP4 (and Microsoft Windows XP SP1 (English Versions)  ArcView 9.2 SP2  Spatial Analyst extension required with flood model. <ul style="list-style-type: none"> <li>• HAZUS installation will allow user to install HAZUS on MS Windows 2000 and XP Service Packs higher than SP4 and SP1 respectively, but HAZUS is not certified to work flawlessly with those service packs.</li> <li>• For specific directions about using HAZUS with Windows XP SP2 please refer to the document DirectionsForUsingHazus-MH_With_WinXP_SP2.doc on the installation DVD or HAZUS-MH installation folder.</li> </ul>		

ArcGIS can be purchased by contacting ESRI, Incorporated at 1-800-447-9778, or online at <http://www.esri.com>. ArcGIS and Windows products should be installed using the manufacturer's instructions. Internet access is highly recommended, although not a system and software requirement. The **HAZUS** operator may occasionally need to access online Help, and current program status reports.

### 1.1.2 Data Requirements

Use of the **FIT** requires the users to provide input spatial data. This includes terrain elevation information in the form of an ArcInfo grid, and flood elevation and floodplain boundary information as ESRI feature classes. The feature classes can exist as a shapefile, ArcInfo coverage, or as part of a geodatabase. All user supplied data must share a common map projection, datums, and units. Sample data is available for users and can be found at the following path C:\Program Files\HAZUS-MH\BIN\FL\FIT\SampleData. The sample data is for Gulf County, FL and Mecklenburg County, NC for coastal and riverine respectively. More detailed descriptions of the input data requirements are provided in Table 1-2 and Table 1-3.

**Table 1-2:  
Riverine Input Data Requirements**

Required Input	Purpose	Spatial Data Format	Rules
Digital elevation model (DEM)	Describe terrain elevations and establish the cell size of all output grids	ArcInfo grid	Should represent bald-earth conditions (i.e., no buildings, trees, etc.)
Flood elevation lines	Contain populated fields for flood elevations and discharges (optional) for one or more return periods.	ArcGIS polyline feature class	<ul style="list-style-type: none"> <li>• Cannot intersect each other</li> <li>• Should intersect the center of the floodplain</li> <li>• No attribute fields named "Along", "Power", or "Skew"</li> </ul>
Floodplain boundary	Define the centerline of flow and act as a guide for determining the floodplain width	ArcGIS polyline feature class	Represented by a single, continuous polygon feature

**Table 1-3:  
Coastal Input Data Requirements**

<b>Required Input</b>	<b>Purpose</b>	<b>Spatial Data Format</b>	<b>Rules</b>
Digital elevation model (DEM)	Describe terrain elevations and establish the cell size of all output grids	ArcInfo grid	Should represent bald-earth conditions (i.e., no buildings, trees, etc.)
Flood hazard polygons	Contain populated fields for the flood elevations and FEMA flood hazard zones of the 100-yr flood	ArcGIS polyline feature class	If AO (sheet flow) zones exist, the depth should be stored in its own field
Analysis boundary	Define the boundary of analysis for all output data	ArcGIS polyline feature class	Represented by a single polygon feature that is completely contained with the DEM domain
Local flood insurance study	Provide stillwater elevations and wave setup at the shoreline	--	At a minimum, the 100-yr stillwater elevation wave setup component should be available

## 1.2 Key Functionality

The **FIT** allows users to input locally available terrain information and flood information (elevation and boundaries) to develop grids of flood depth and flood elevation. This is accomplished through a series of user interface dialogs that guide the user through the process while gaining critical user input. Key features of the **FIT** are:

- Multi-hazard analysis: able to process flood hazard data for both riverine and coastal settings.
- Accepts user-supplied data: flexible enough to accept a variety of user-supplied terrain and flood hazard data.
- Flood surface interpolation: algorithms provide a means to interpolate flood elevations between cross-sections (riverine) and across base flood elevation polygons (coastal).
- Flood depth analysis: calculates flood depth grid(s) throughout the area of analysis.
- Flood frequency analysis: once the initial flood depth analyses are performed, depth grids for user-specified return periods can be interpolated.
- Flood-induced erosion analysis (coastal hazard only): algorithms model potential failure of the frontal dune in order to calculate a grid of flood-induced erosion depth. The **FIT** procedure is similar to the procedure used in FEMA coastal flood studies.
- Guidance via help functions to help users transform their flood hazard data into the formats required by the **FIT**.

It should be noted what functionality the **FIT** does not provide, namely hydrologic and hydraulic calculations. These computations must be completed elsewhere, and the results provided to the **FIT** as input data (see Section 1.1.2).

### 1.3 Overview of the *FIT* Riverine Methodology

The riverine portion of the *FIT* was developed to allow users of *HAZUS* to incorporate results of their own, stream-specific, hydraulic models. The primary *FIT* output is a flood depth grid or a set of such grids formatted for use in *HAZUS*. The spatial data required to run the riverine portion of the *FIT* are a digital elevation model (DEM), a set of polylines (cross sections) attributed with flood elevations, and a polygon that defines a representative floodplain boundary. The DEM is an ArcInfo grid; the polyline and polygon files are shapefiles.

#### Input Floodplain Boundary

The user is required to identify up- and downstream limits of study and the shapefile field(s) that contains the elevation data in the polyline shapefile. If the floodplains are represented by more than one polygon, the user is required to identify the polygon associated with the study area. The floodplain boundary polygon need not be associated with any particular flood. It is used by the *FIT* only to define a “smooth” line representing the general flow path of floodwater. Only one polygon can be associated with a study reach. Floodplains that are disconnected (by a road crossing, for example) must be somehow connected (merged) or studied as two reaches.

#### Centerline of Flow

Once the stream limits have been chosen, the program will define a polyline from the upstream limit to the downstream limit. That polyline is, in a sense, the centerline of the floodplain. It is the aforementioned smooth line representing the general flow path of floodwater. Note that the program uses centerline to identify cross sections within the reach. Specifically, only cross section lines that cross the centerline are considered in subsequent analyses. It is important to ensure that all cross sections within a reach cross the centerline. Note that lines that cross the floodplain polygon necessarily cross the centerline.

#### Bounding Polygon

An initial buffer is computed around the centerline and the user is prompted to increase and/or decrease the buffer until satisfied that the conveyance area of the floodplain of interest is contained within the buffer. The chosen buffer defines the extent to which flood depths will be calculated and, therefore, is referred to as the bounding polygon. The extent of the floodplain boundary shapefile may help in guiding the decision on how large to make the bounding polygon.

The lengths of the cross section lines and the limits do not restrict the size of bounding polygon. If necessary, the program will extend cross-section lines to the bounding polygon. If necessary, the cross-section lines are extended in a manner that preserves a sense of alignment perpendicular to flood flow. The limits are extended in a straight line following the alignment at the ends of each respective limit. Users should try to avoid drawing stream limits that cross each other, intersect cross sections, or otherwise cut off portions of the bounding polygon pertinent to describing the floodplain.

### Non-Conveyance Areas

Certain low-lying areas adjacent to the floodplain, such as tributary streams, that do not convey but, rather, retain floodwater (pond) at the flood elevation in the conveyance part of the floodplain, need not be included within the bounding polygon. The *FIT* provides an analysis option for including such areas inside and outside of the bounding polygon. The ideal bounding polygon contains all portions of (different frequency) floodplains being analyzed and, also, minimizes the areas subject to ponding.

### Interpolation of Additional Hazard Grids

If the cross sections are attributed with multiple flood elevations, the *FIT* uses the information supplied for the initial analyses to develop subsequent flood depth grids. That is, subsequent flood depth grids can be developed without re-entering reach limits and choosing bounding polygons. If cross sections are attributed with at least three flood elevations and corresponding discharge values, the *FIT* offers an option to interpolate other flood depth grids.

### Modeling Tips

The study reach is defined by the choice of up- and downstream limits. In some situations, subdividing a reach into shorter reaches can improve the efficiency (run time) of the *FIT*. Subdividing a reach into reaches covered by bounding polygons of different sizes will yield results quicker than using the largest bounding polygon for the entire reach. In general, reaches should be chosen to include relatively homogeneous floodplain widths. Reaches should overlap enough to ensure that there are no gaps in coverage of the floodplain.

Highly meandering floodplain configurations may warrant special attention. If the flow centerline (not the stream) has a horseshoe-shaped meander, increasing the buffer will, at some distance, create a discontinuity in the bounding polygon. An “island” will form within the bounding polygon somewhere within the meander (inside the horseshoe). The interpolation algorithm in the *FIT* does not operate properly in such situations. Increasing the bounding polygon beyond that limiting size will result in error messages. If the bounding polygon must be increased beyond that limit, the meander should be analyzed piece-wise, thereby removing the “horseshoe” shape within any reach.

In order to analyze a stream network piece-wise, each partial analysis should begin by specifying a new working directory in the Project Setup and Validation dialog. After each individual analysis is complete, the results can be combined using the Merge FIT Projects menu item.

## 1.4 Overview of the *FIT* Coastal Methodology

The coastal portion of the *FIT* was developed to allow users of *HAZUS* to incorporate data from coastal flood hazard maps produced by FEMA or produced by other sources. The result of using the *FIT* is a flood depth grid or a set of such grids formatted for use in *HAZUS*. The data required to run the coastal portion of the *FIT* are a digital elevation model (DEM), a set of polygons (areas subject to flooding) attributed with base flood elevations (BFE) and FEMA flood hazard zones (e.g., zone VE, zone AE, etc.) and a polygon representing the analysis boundary. The DEM is a grid; the polygon files are Shapefiles. The flood elevation polygons used by the coastal *FIT* must be associated with the base flood (100-year flood). They are used by the *FIT* to generate a 100-year flood elevation grid, and form the basis for all other return period flood surfaces calculated by the *FIT*.

### Shoreline Characterization

The user is required to identify all coastal flood sources that will be considered by *HAZUS*, and to draw a shoreline associated with each flood source. The shoreline drawn by the user should be a general depiction of the shoreline, and should not be a detailed rendering. In tidal areas, the shoreline drawn should represent the approximate mean sea level shoreline; in the Great Lakes the shoreline should be drawn at approximately the International Great Lakes Datum (IGLD) chart datum. If the user has a local map layers depicting the water line, this can be used as a guide when drawing the generalized shoreline.

The user must then divide each shoreline into segments of common physical characteristics and wave exposure. The shoreline types available for user selection include: rocky bluff; sandy bluff, little beach; sandy beach, small dune; sandy beach, large dune; open wetland; erosion protection structure. If the user selects an erosion protection structure (e.g., seawall or revetment) for a shoreline segment, the user must assign a level of protection afforded by the structure (i.e., a flood return period, below which the structure will not fail, and below which the structure will protect the uplands from flooding and erosion).

The user must provide the 100-year stillwater elevation at each shoreline segment, along with any contribution from wave setup (the stillwater elevation and wave setup information are published by FEMA in the Flood Insurance Study report -- FIS-- for each coastal community). The *FIT* relies upon the 100-year stillwater elevation (without setup) to calculate 10-year, 50-year and 500-year stillwater elevations. The user can edit or replace these elevations with values taken directly from the FIS, if available; otherwise, the *FIT* will use the calculated values, which are based on nationwide default data. Ultimately, the *FIT* can use the stillwater elevation values -- calculated or input by the user -- to calculate 10-year, 50-year, 500-year and interpolated flood elevation grids.

The *FIT* relies upon the user segmentation to differentiate between those segments that will be subject to flood-induced erosion and those that won't. The *FIT* will generate shore-perpendicular transects from each shoreline segment. The transects are located at a pre-determined spacing and extend inland from the shoreline. The user is free to add and delete new transects if so desired.

### Frontal Dune Erosion

The *FIT* will create a profile (of ground elevation versus distance inland from the shoreline) for each transect crossing an erodable shoreline segment, and with sufficient wave action to cause erosion of dunes and bluffs or failure of erosion protection devices during the base flood. The user may select the peak and toe of the dune/bluff, or accept the *FIT* selections. The *FIT* will then calculate an eroded ground profile along each transect, and interpolate an eroded ground elevation grid.

### Output Hazard Grids

The *FIT* will calculate the flood depth grid (i.e., the difference between the flood elevation grid and the eroded ground elevation grid) for the 100-year flood and for other return periods selected by the user. This information will be passed to *HAZUS*, along with other data (shoreline characteristics, transect data, stillwater elevations, flood hazard zone information, etc.).

The flood depth grids created by the *FIT* will be used by *HAZUS* with a suite of flood depth-damage functions to calculate flood damage. The vertical erosion grid calculated by the *FIT* (i.e., the vertical difference between the original ground elevation grid and the eroded ground elevation grid) will also be passed to *HAZUS*, for use with an erosion depth-damage function to calculate erosion damage.

### Modeling Tips

The study areas are subject to flooding from more than one coastal flood source. For example, a barrier island may be exposed to flooding from the open ocean and a bay. In such cases, *FIT* coastal analyses should be completed separately for each flood source. In order to analyze an area with multiple flood sources, each partial analysis should begin by specifying a new working directory in the Project Setup and Validation dialog and delineating and characterizing a new shoreline with the Shoreline Wizard. After each individual analysis is complete, the results can be combined using the Merge *FIT* Projects menu item.

## 2 Using FIT

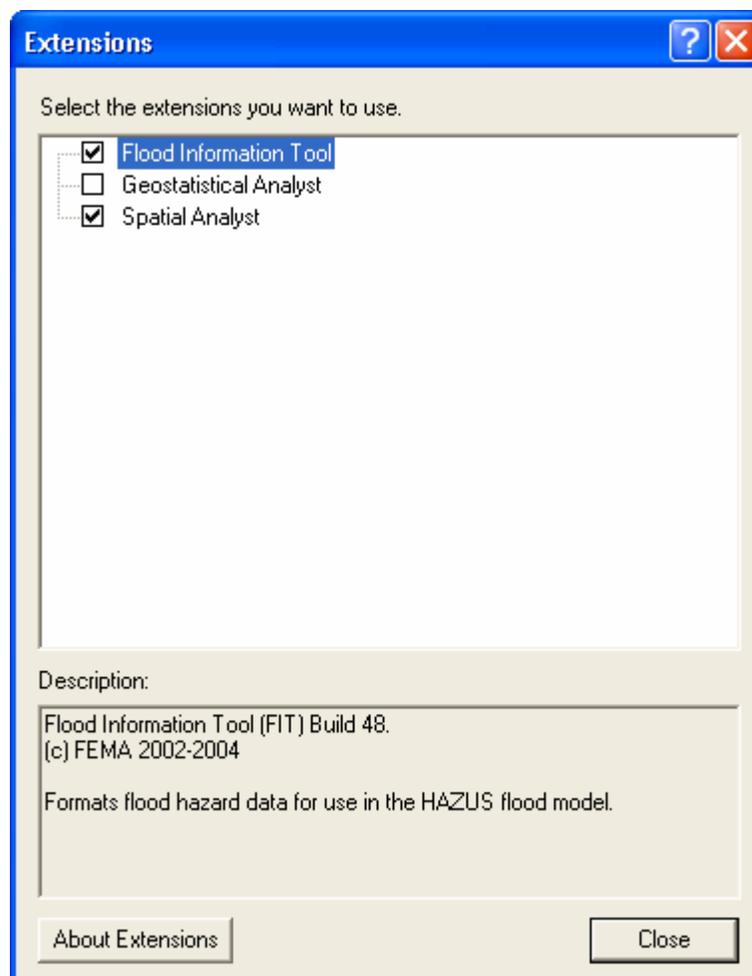
### 2.1 Getting Started

⇒ Start the ArcMap application.

To access the **FIT** and the Spatial Analyst extensions:

⇒ Select **Extensions...** from the ArcMap's **Tool** menu.

⇒ Click on the check boxes for **Spatial Analyst** and the **Flood Information Tool** as shown in Figure 2-1.



**Figure 2-1: ArcMap's Extensions Dialog**

The *Flood Information Tool* that contains the menu items *HAZUS\_FIT*, *Riverine* and *Coastal* is added to ArcMap's menu. All of *FIT*'s functionality is accessed through the *Flood Information Tool* toolbar.



**Figure 2-2: Flood Information Tool Toolbar**

- ⇒ If the ***FIT*** toolbar is not displayed, select **Toolbars** from the **View** menu.
- ⇒ Click on **Flood Information Tool**.
- ⇒ Repeat to display the **Spatial Analyst** toolbar but select **Spatial Analyst** instead of **Flood Information Tool**.
- ⇒ Adjust the placement of the toolbars by dragging and dropping them to a convenient place on the screen. The *Flood Information Tool* may be placed on the menu bar if desired.

## 2.2 Menu Options

### 2.2.1 HAZUS-FIT Menu

**Table 2-1:  
HAZUS-FIT Menu Options**

HAZUS-FIT Menu Options	Purpose	Availability
<b>Project Setup and Validation</b>	Allows the user to select the map layers to be used for flood hazard analysis, identify characteristics of them and view their projection. The <b>FIT</b> verifies that the input map layers share common vertical units, vertical datums, and map projections. See Section 2.3.	Available at all times.
<b>Merge FIT Projects</b>	Allows users to merge output depth and elevation grids as well as output shapefiles from separate <b>FIT</b> analyses. See Section 2.6.	Available at all times.
<b>FIT Help</b>	Gives the user access to the online help for the <b>FIT</b> .	Available at all times.
<b>About FIT</b>	Provides access to the version number of <b>FIT</b> and copyright information.	Available at all times.

## 2.2.2 Riverine Menu

If the riverine hazard has been selected and validated on the *Project Setup and Validation dialog*, the **Riverine** menu options are enabled. (Shown in Figure 2-3.) The following is a brief description of each **Riverine** menu option and when it is available on the **Riverine** menu.

**Table 2-2:**  
**Riverine Menu Options**

Riverine Menu Options	Purpose	Availability
<b>Depth Grid Wizard</b>	Allows the user to establish the analysis bounding polygon and produce flood elevation and depth grids. See Section 2.4.1.	Available after a project has been selected, defined as a Riverine hazard and validated using the <b>Project Setup and Validation</b> option on the <b>HAZUS-FIT</b> menu.
<b>Backwater Analysis</b>	Performs map operations to identify and establish flood elevations for areas of potential backwater. See Section 2.4.2.	Available after the initial depth grids have been produced using the <b>Depth Grid Wizard</b> option on the <b>Riverine</b> menu.
<b>Interpolate New Depth Grid</b>	Allows the user to specify additional return periods to be interpolated and a new depth grid created for each. The user can select flood return periods between 2 years and 1000 years. See Section 2.4.3	Available when at least 3 return periods with elevation and discharge values are added on the <b>Depth Grid Wizard's Flood Elevation and Discharge Fields dialog</b> .

### 2.2.3 Coastal Menu

The **Coastal** menu options on the *Flood Information Tool* toolbar are available when a coastal hazard project has been selected and validated on the *Project Setup and Validation dialog* shown in Figure 2-4. The following identifies the **Coastal** menu options and when each is enabled on the **Coastal** menu.

**Table 2-3:  
Coastal Menu Options**

<b>Coastal Menu Options</b>	<b>Purpose</b>	<b>Availability</b>
<b>Build 100-Yr Elevation Grid</b>	Calculates and builds a 100-yr. elevation grid. See Section 2.5.1.	Available after a project has been selected, defined as Coastal and validated using the <b>Project Setup and Validation</b> option on the <b>HAZUS-FIT</b> menu.
<b>Shoreline Wizard</b>	Selection of the Shoreline Wizard launches a series of dialogs designed to help the user identify and characterize the shoreline of interest. See Section 2.5.2.	Available when a 100-yr. elevation grid has been created using the <b>Build 100-Yr Elevation Grid</b> option on the <b>Coastal</b> menu.
<b>Edit Transects</b>	Selection of <b>Edit Transects</b> allows the user to create new transects, select and delete new transects or apply the transects proposed by the <b>FIT</b> along their shoreline. See Section 2.5.3. (Optional.)	Available after the <i>Shoreline Wizard</i> has been completed using the <b>Shoreline Wizard</b> option on the <b>Coastal</b> menu.
<b>Frontal Dune Analysis</b>	The <b>Frontal Dune Analysis</b> option allows the user to select the dune toe and peak for each erodable transect. See Section 2.5.4. (Optional)	Available after the <i>Shoreline Wizard</i> has been completed using the <b>Shoreline Wizard</b> option on the <b>Coastal</b> menu.
<b>Calculate Hazard Grid</b>	The <b>Calculate Hazard Grid</b> option allows the user to specify additional return periods to be interpolated and new depth grid created for each. The user can select flood return periods between 10-year and 500-year. See Section 2.5.5.	Available after the <i>Shoreline Wizard</i> has been completed using the <b>Shoreline Wizard</b> option on the <b>Coastal</b> menu.

## 2.3 Project Setup and Validation

The *Project Setup and Validation dialog* allows the user to identify the input map layers to be used in the flood hazard analysis. Users can also review the projection of their map layers and ensure that they share a projection, units, and datum as required for the analysis.



The *Project Setup and Validation dialog* itself will not allow the modification or the manipulation of the data. To manipulate existing data units, projection or datum, you will need to use the functionality in ArcCatalog and/or ArcToolbox.

- ⇒ Click on ArcMap's **File / New** menu option to start a new ESRI ArcMap document (.mxd).
- ⇒ Add the required input data layers to the map by clicking **File/Add Data** menu option and browsing to the location of the files. (See Section 1.1.2.). The sample data for riverine and/or coastal FIT can be found by navigating to HAZUS-MH/BIN/FL/SampleData.

To open the *Project Setup and Validation dialog*:

- ⇒ Select **Project Setup and Validation** from the **HAZUS\_FIT** menu on the *Flood Information Tool* toolbar.

*The Project Setup and Validation dialog appears over the active map window. By default, the General Tab with Riverine Hazard radio button selected is displayed. With Riverine selected as the hazard on the General Tab, the Project Setup and Validation Dialog consists of four tabs: General, Ground Surface, Flood Surface and Floodplain Boundary as shown in Figure 2-3. If Coastal (Coastal radio button) is selected as the hazard on the General Tab, the Project Setup and Validation Dialog consists of four tabs: General, Ground Surface, Flood Surface, and Analysis Boundary as shown in Figure 2-4.*



If an area is subject to both riverine and coastal flooding, separate analyses must be conducted with the Riverine and Coastal **FIT**; the results are combined later in the *HAZUS* flood model itself.

### Project Setup and Validation –Riverine:

- **General Tab:** Allows the user to select the hazard and define the working directory. See Figure 2-3.
- **Ground Surface Tab:** Allows the user to specify the map layer for their digital terrain information, select the source, elevation units, vertical datum, and enter other descriptive parameters. The projection, horizontal units and cell size are also displayed. See Figure 2-5 and Figure 2-6.
- **Flood Surface Tab:** Displays the flood elevation map layer information for the user to check and select the map layer, source, elevation units, vertical datum, and other descriptive parameters. See Figure 2-7.

- **Floodplain Boundary Tab:** Displays the floodplain boundary map layer information for the user to select the map layer and source, and other descriptive parameters. See Figure 2-9.

### **Project Setup and Validation – Coastal:**

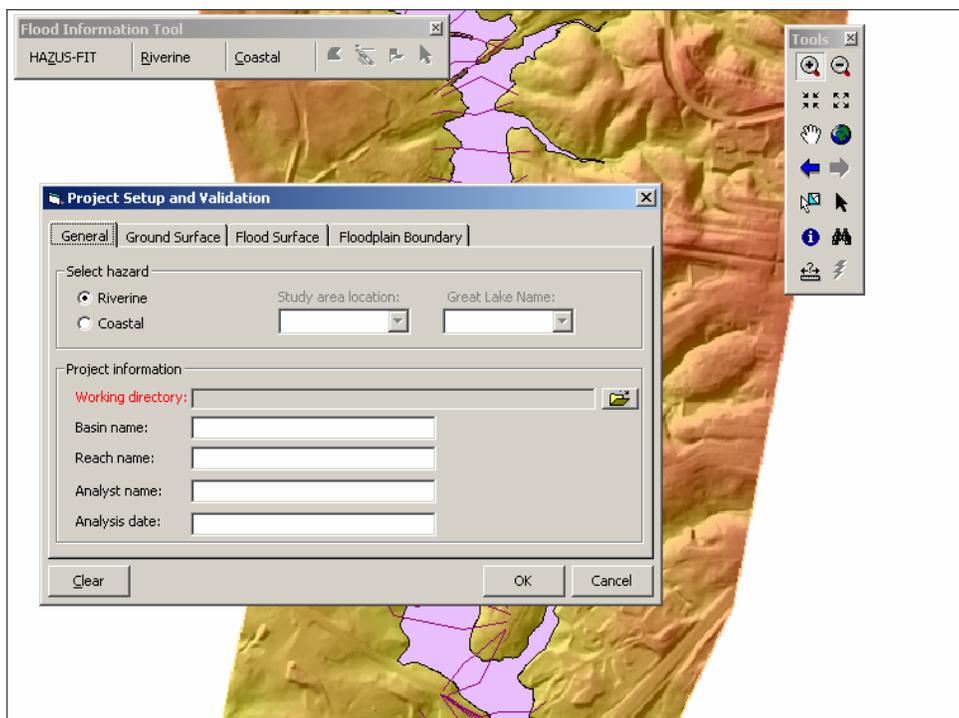
- **General Tab:** Allows the user to select a hazard. It also allows the user to define the study area geographic location (i.e., Great Lakes, Atlantic Coast, etc.), and working directory. See Figure 2-4.
- **Ground Surface Tab:** Allows the user to specify the map layer for their digital terrain information, select the source, elevation units, vertical datum, and enter other descriptive parameters. The projection, horizontal units and cell size are also displayed. See Figure 2-5 and Figure 2-6.
- **Flood Surface Tab:** Displays the flood elevation map layer information for the user to check and select the map layer, source, elevation units and vertical datum. See Figure 2-7 through Figure 2-8.
- **Analysis Boundary:** Displays the analysis boundary map layer information for the user to select the map layer and source, and other descriptive parameters. See Figure 2-10.

### 2.3.1 General Tab

The General Tab allows the user to select a hazard, and define the project name and working directory.

⇒ If not already displayed, click on the **General Tab**.

*The General Tab is displayed as shown in Figure 2-3.*



**Figure 2-3: Project Setup and Validation – General Tab Dialog for Riverine Hazard**



Labels of required fields are displayed in **Red**.

⇒ Select the desired hazard by clicking on the appropriate radio button in the Select Hazard group box.

## Riverine Hazard

Complete the project information as follows:

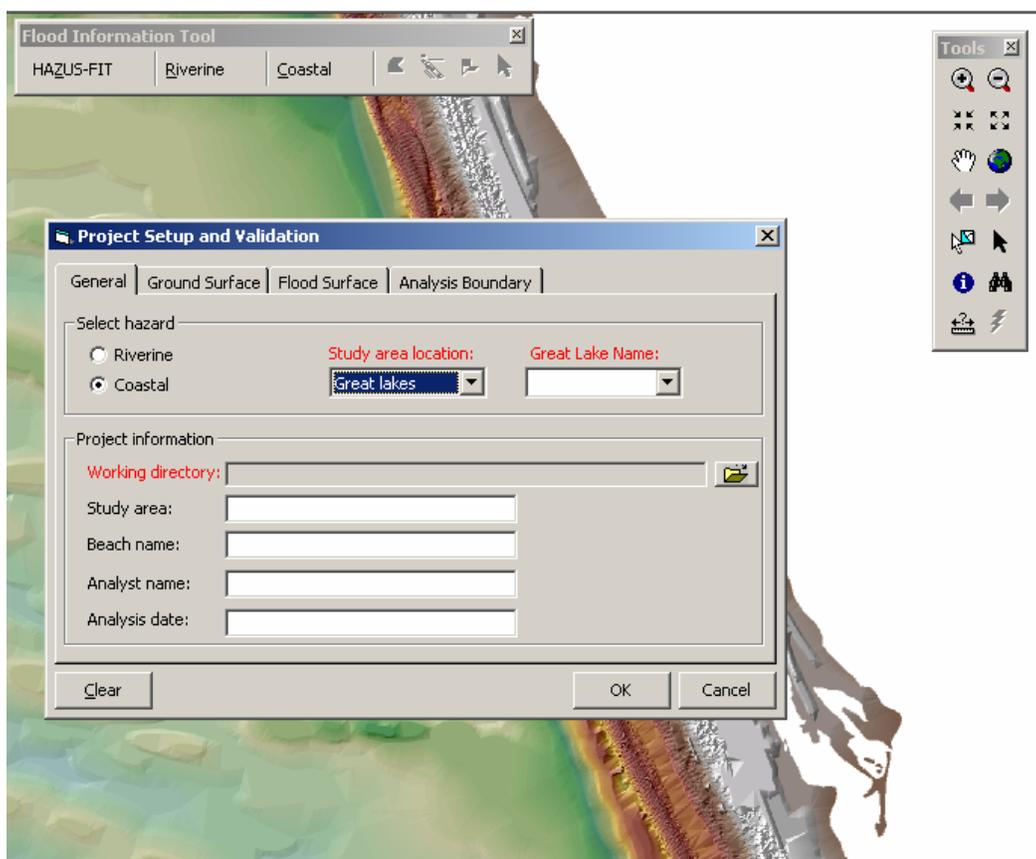
- ⇒ Click on the Open Directory icon for **Working directory** to browse to the working directory. Single click on the appropriate directory to highlight and click **Select**. Do not double click. (Required) A new folder can be created by clicking the **New Folder** button within the *Select Working Directory dialog*.

The **Working directory** is where the FIT output files will be stored.

- ⇒ Type in the **Basin name**. (Optional)
- ⇒ Type in the **Reach name**. (Optional)
- ⇒ Enter your name and the analysis date. (Optional)

## Coastal Hazard

If Coastal is selected, the *Study area location* list box is enabled as shown in Figure 2-4.



**Figure 2-4: Project Setup and Validation – General Tab Dialog for Coastal Hazard**

- ⇒ Select the study area from the **Study area location** list box. (Required)

*If Great Lakes is selected from the Study area location dropdown list, the Great Lake Name dropdown list box is enabled as a required field.*

- ⇒ If needed, select the Great Lake name from the **Great Lake Name** dropdown list box.

The user must select one of six choices: Lake Erie, Lake Huron, Lake Michigan, Lake Ontario, Lake Superior, or Other. A choice of "Other" indicates the study shoreline does not lie on one of the main lakes, and when the ordinary low water level at the study shoreline is substantially different (i.e., more than 5 feet) than the ordinary low water level on the nearest main lake. This situation may arise along hydraulic connections between the main lakes, or Lake St. Clair. If "Other" is selected, the Reference Elevation field on the flood Surface Tab is enabled and a value must be entered (Figure 2-8).

Complete the project information as follows:

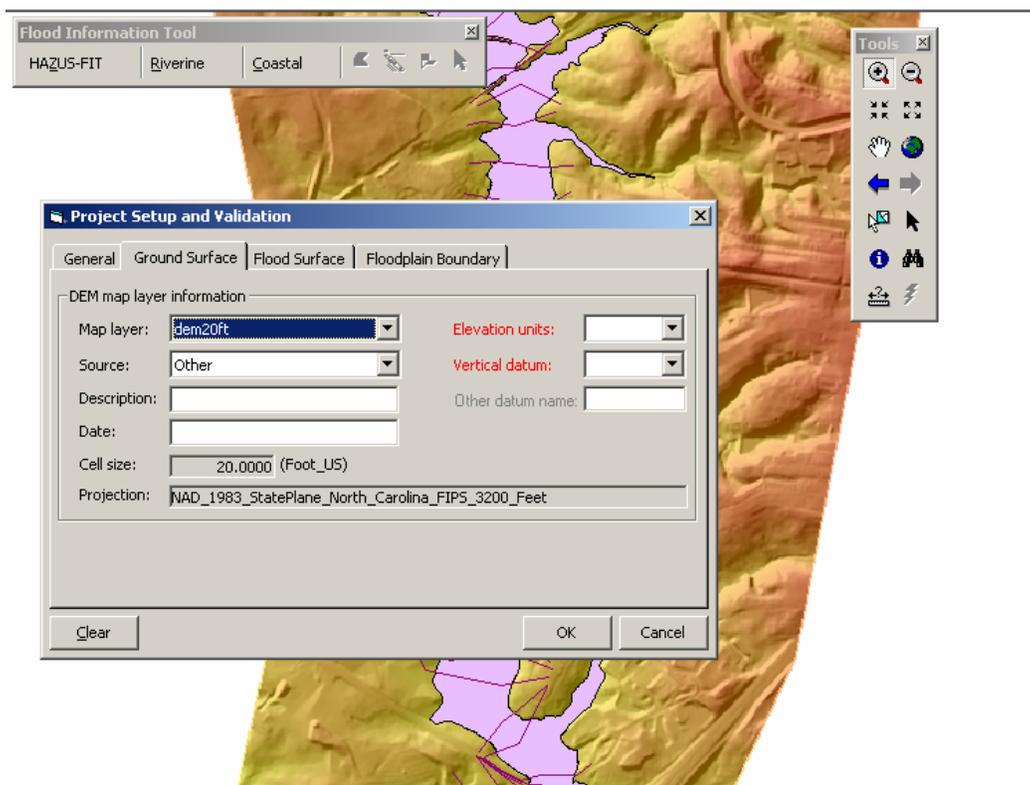
- ⇒ Click on the Open Directory icon for **Working directory** to browse to the working directory. Single click on the appropriate directory to highlight and click **Select**. Do not double click. (Required) A new folder can be created by clicking the **New Folder** button within the *Select Working Directory dialog*.
- ⇒ Type in the **Study area**. (Optional)
- ⇒ Type in the **Beach name**. (Optional)
- ⇒ Enter your name and the analysis date. (Optional)

## 2.3.2 Ground Surface Tab

The Ground Surface Tab allows the user to specify the map layer for their digital terrain information, and select the source, elevation units and vertical datum. The projection, horizontal units and the cell size of the grid are also displayed. The Ground Surface Tab is the same for a riverine hazard and a coastal hazard.

⇒ Click on the **Ground Surface Tab**.

*The Ground Surface Tab is displayed as shown in Figure 2-5.*



**Figure 2-5: Project Setup and Validation – Ground Surface Tab Dialog**



Labels of required fields are displayed in **Red**.

⇒ Select the appropriate map layer from the **Map layer** dropdown list which displays all raster layers in the active data frame.

Sample data: Select **dem20ft** (riverine) or **dem3meters** (coastal).

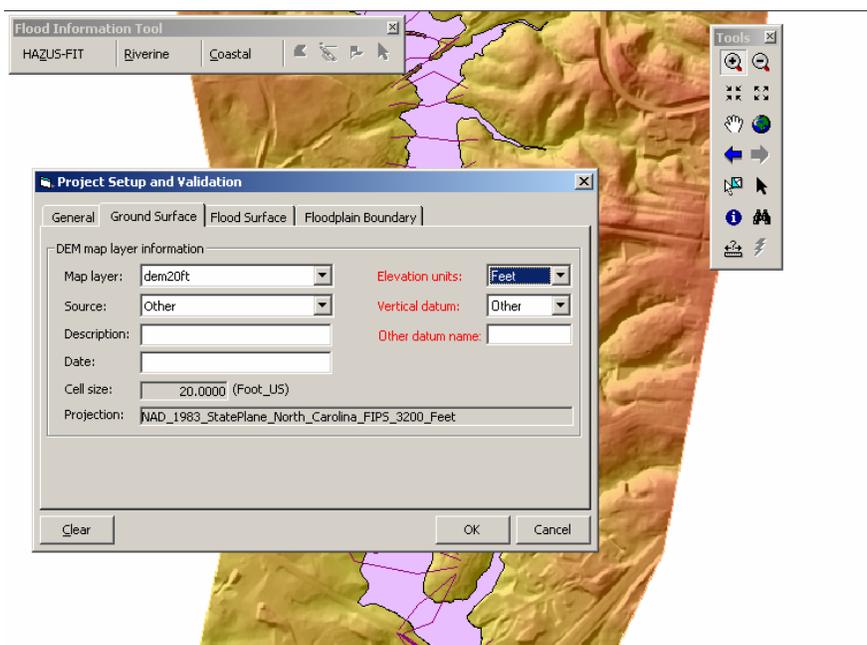
⇒ Select the elevation units from the **Elevation units** dropdown list. (Required)

Sample data: Select **Feet** (riverine) or **Meters** (coastal).

⇒ Select the vertical datum from the **Vertical datum** dropdown list. (Required)

Sample data: Select **NAVD88** (riverine) or **NGVD29** (coastal).

If *Other* is selected for Vertical datum, the *Other datum name* is enabled as shown in Figure 2-6.



**Figure 2-6: Project Setup and Validation – Ground Surface Tab Dialog with Vertical Datum as Other**

⇒ Enter the **Other datum name** as required. (Required if Vertical datum is Other)



The Elevation units, Vertical datum and Other datum name must be the same on the Ground Surface Tab and the Flood Surface Tab.

⇒ Select the source from the **Source** dropdown list. (Optional)

⇒ Enter the description in the **Description** text box. (Optional)

⇒ Enter the layer date in the **Date** text box. (Optional)

*The remaining boxes display the following map layer information from the raster projection file: cell size and map projection.*



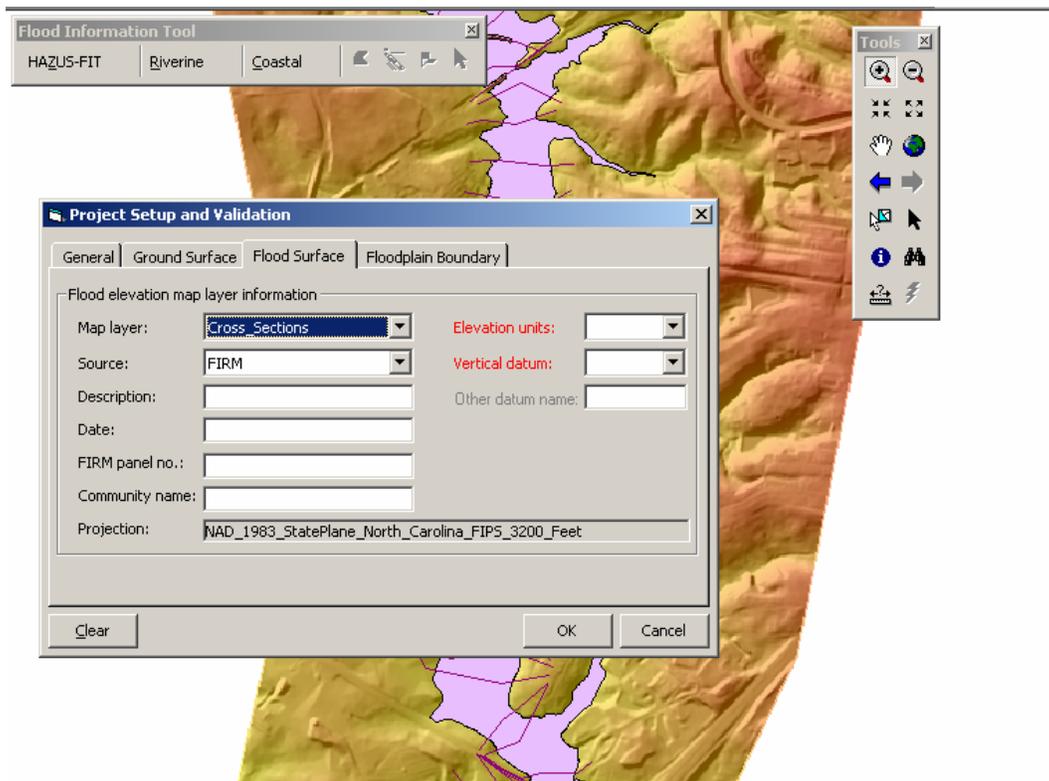
Coastal users should keep in mind that every shore-normal transect, that would be automatically drawn in later stages on the user drawn shoreline, needs at least 500 ft. of length landward of the shoreline. If there are narrow islands in the area of interest, the DEM should NOT be clipped to islands and extend towards sea with elevation values other than “No data”.

### 2.3.3 Flood Surface Tab

The Flood Surface Tab allows the user to identify characteristics of the flood elevation map layer, including the name, source, elevation units and vertical datum. The projection of the selected flood elevation map layer is also displayed.

⇒ Click on the **Flood Surface Tab**.

*The Flood Surface Tab is displayed as shown in Figure 2-7.*



**Figure 2-7: Project Setup and Validation – Flood Surface Tab Dialog**



Labels of required fields are displayed in **Red**.

⇒ Select the appropriate map layer from the **Map layer** dropdown list which displays all polyline (riverine) or polygon (coastal) map layers in the active data frame.

Sample data: Select **Cross\_Sections** (riverine) or **s\_fld\_haz\_ar** (coastal).

⇒ Select the elevation units from the **Elevation units** dropdown list. (Required)

Sample data: Select **Feet** (riverine) or **Meters** (coastal).

⇒ Select the vertical datum from the **Vertical datum** dropdown list. (Required)

Sample data: Select **NAVD88** (riverine) or **NGVD29** (coastal).

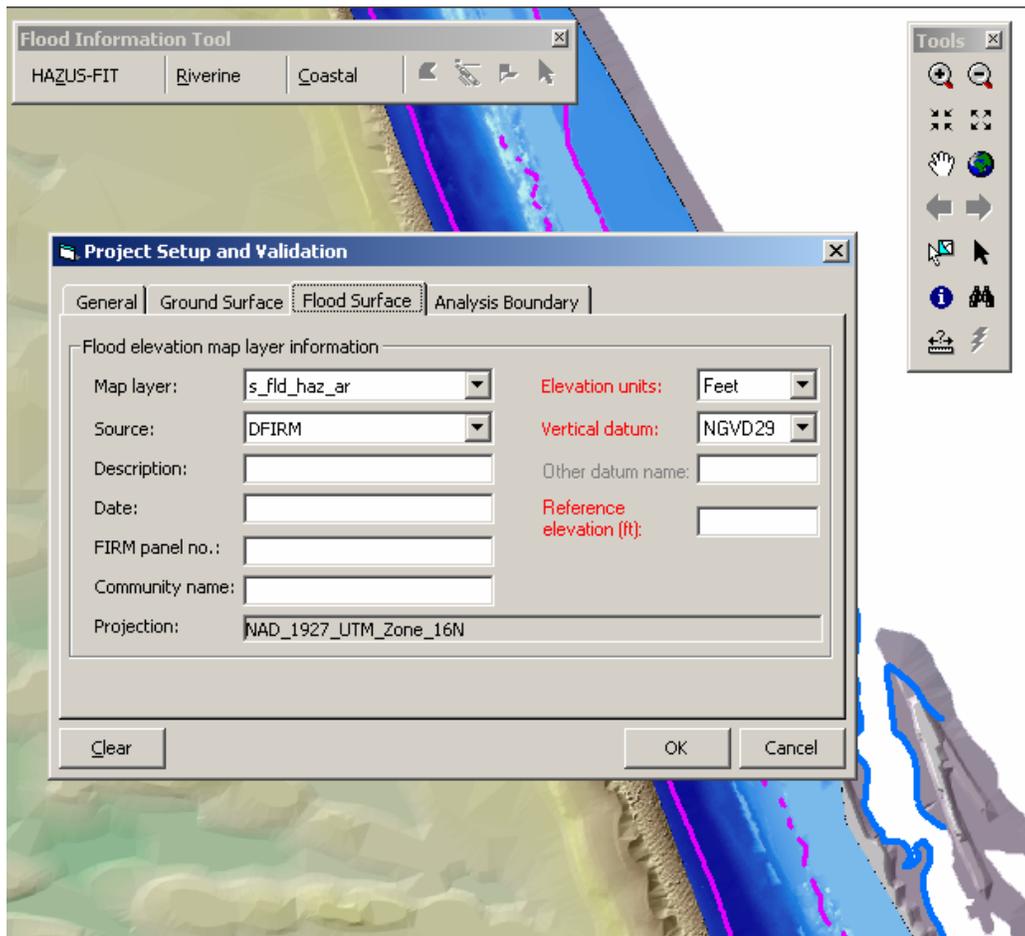
*If Other is selected for Vertical datum, the Other datum name is enabled.*

⇒ Enter the **Other datum name** as required. (Required if Vertical datum is Other)



The Elevation units, Vertical datum and Other datum name must be the same on the Ground Surface Tab and the Flood Surface Tab.

*When setting up a Coastal hazard and Great lakes is selected as the Study area location and “Other” is selected from the dropdown list box on the General Tab, the Reference elev: field appears and becomes a required field as shown in Figure 2-8.*



**Figure 2-8: Project Setup and Validation – Flood Surface Tab Dialog for Coastal – “Great Lakes” Study Area and “Other” Great Lake Name**

- ⇒ Select the source from the **Source** dropdown list. (Optional)
- ⇒ Enter the description in the **Description** text box. (Optional)
- ⇒ Enter the shapefile creation date in the **Date** text box. (Optional)
- ⇒ Enter the FIRM Panel no in the **FIRM Panel no.** text box. (Optional)
- ⇒ Enter the community name in the **Community name** text box. (Optional)
- ⇒ Enter the reference elevation in the **Reference elev:** text box. (Enabled and required for Great Lakes study area and “Other” great lake). Note that reference elevation should be entered in feet and be between 0 and 601 feet. The reference elevation input by the user should be the ordinary low water elevation (similar to IGLD Chart Datum) relative to NGVD29. The chart datums in Table 2-4 may be of assistance if a specific chart datum for the study shoreline cannot be found.

**Table 2-4:**  
**Default Reference Elevations for the Great Lakes**

Lake	Elevation
Erie	570 ft.
Huron	578 ft.
Michigan	578 ft.
Ontario	244 ft.
St. Clair	573 ft.
Superior	601 ft.



The FIT user reference elevations along with the 100-yr. Stillwater elevation to calculate the 10 yr, 50-yr, and 500-yr Stillwater and flood elevations

*The remaining box displays the Projection map layer information .*



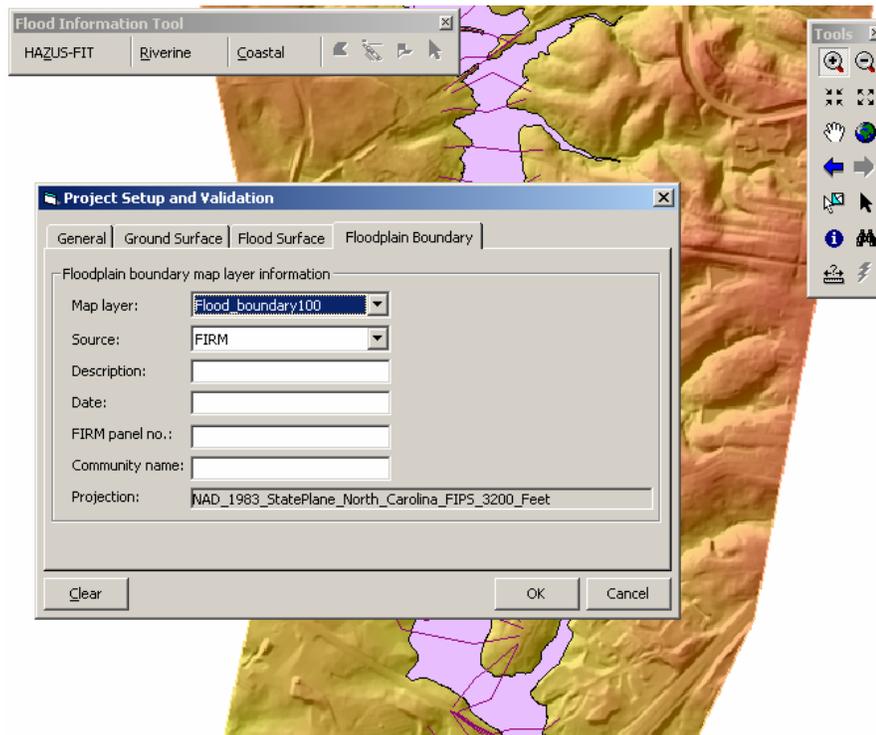
Coastal users should note that each valid BFE polygon they provide, should have a BFE greater than the reference elevation.

### 2.3.4 Floodplain Boundary Tab (Riverine Only)

The *Floodplain Boundary Tab* allows the user to identify the characteristics of their flood elevation information. The projection of the selected flood boundary map layer is also displayed. To access the *Floodplain Boundary Tab*:

- ⇒ Click on the **Floodplain Boundary Tab**.

*The Floodplain Boundary Tab as shown in Figure 2-9 is displayed. This dialog is applicable for the Riverine Hazard only.*



**Figure 2-9: Project Setup and Validation - Floodplain Boundary Tab**

- ⇒ Select the appropriate map layer from the combo box labeled **Map layer**. This combo box displays all polygon layers in the active data frame.

Sample data: Select **Flood\_boundary100** (riverine).

- ⇒ Select the source from the **Source** combo box dropdown list. (Optional)
- ⇒ Enter the description in the **Description** text box. (Optional)
- ⇒ Enter the date in the **Date** text box. (Optional)
- ⇒ The text box labeled **FIRM panel no.** allows the community to input their FIRM panel number. (Optional)

- ⇒ As needed, enter the community name from the FIRM panel in the text box labeled **Community name**. (Optional)

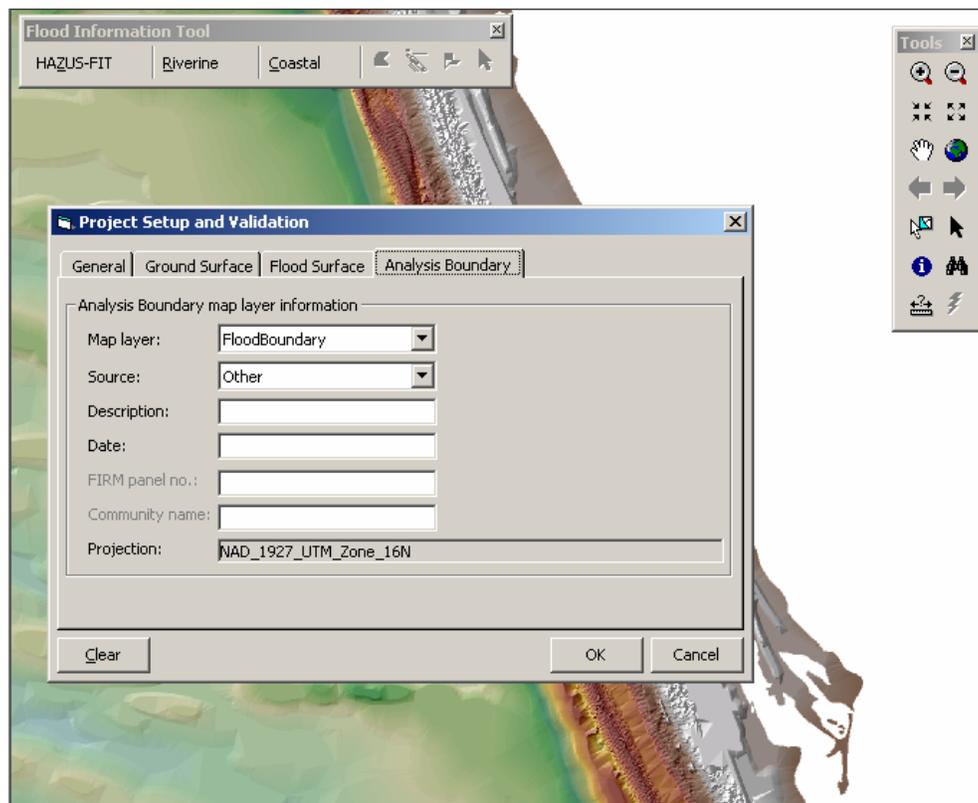
### 2.3.5 Analysis Boundary Tab (Coastal Only)

The Analysis Boundary polygon is used to specify where the hazard should be calculated by FIT. It should be a single feature in a polygon shapefile which consists of one single ring (doughnut shaped polygon, or polygons with multiple disjointed pieces are not allowed). In general the Analysis Boundary polygon should not be too narrow and should allow 1500 ft. long transects to be built inside it. Also it should not be much greater than the area that the user plans to draw the shoreline.

The *Analysis Boundary Tab* allows the user to set the analysis boundary map layer and provide descriptive information about it. To access the *Analysis Boundary Tab*:

- ⇒ Click on the **Analysis Boundary Tab**.

*The Analysis Boundary Tab as shown in Figure 2-10 is displayed. This dialog is applicable for the Coastal Hazard only.*



**Figure 2-10: Project Setup and Validation - Analysis Boundary Tab**

- ⇒ Select the appropriate map layer from a combo box labeled **Map layer**. This combo box displays all polygon layers in the active data frame.

Sample data: Select **AnalysisBound** (coastal).

- ⇒ Select the source from the **Source** combo box dropdown list. (Optional)
- ⇒ Enter the description in the **Description** text box. (Optional)

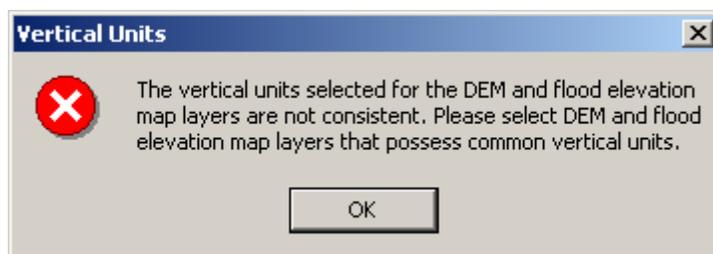
⇒ Enter the date in the **Date** text box. (Optional)

### 2.3.6 Completion of the Project Setup and Validation Process - Riverine and Coastal

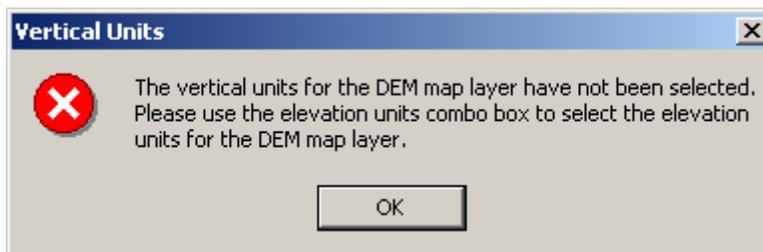
- ⇒ Click **Cancel** to close the *Project Setup and Validation dialog* and discard any changes made or click **Clear** to remove all user input from all of the Project Setup and Validation tabs. When **Clear** is used the *Project Setup and Validation dialog* remains open.
- ⇒ Click **OK** to save edits and close the *Project Setup and Validation dialog*.

*The critical map layer information is checked by the FIT to determine if there are any data conflicts with different map units or if any required data missing.*

*If conflicts or missing data are found, an error message is displayed to notify the user of the problem and which fields or key parameters need to be reviewed.*



**Figure 2-11: Data Conflict Error Message**



**Figure 2-12: Vertical Units Missing Error Message**

Once the project has been set up and validated, additional user input is required for the analysis. The information needed for a riverine hazard is different from the information required for a coastal hazard.



It is recommended that the user save the file before proceeding to the next menu option.

⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

- **Riverine Hazard:** Proceed to Section 2.4.
- **Coastal Hazard:** Proceed to Section 2.5.

## 2.4 Riverine Analysis



It is recommended that the user review the Riverine **FIT** methodology discussion in Section 1.3 above. This review will help the user anticipate the actions requested by the **FIT** and the resulting action taken by the **FIT**.

If the riverine hazard was selected on the *General Tab* on the *Project Setup and Validation dialog*, the **Riverine** menu options are available. See Section 2.2.2 for a brief description of each **Riverine** menu option and when it is available.



The FIT's title bar offers updates to the user on which process is currently being handled during periods of data review, analyses, etc.

### 2.4.1 Depth Grid Wizard

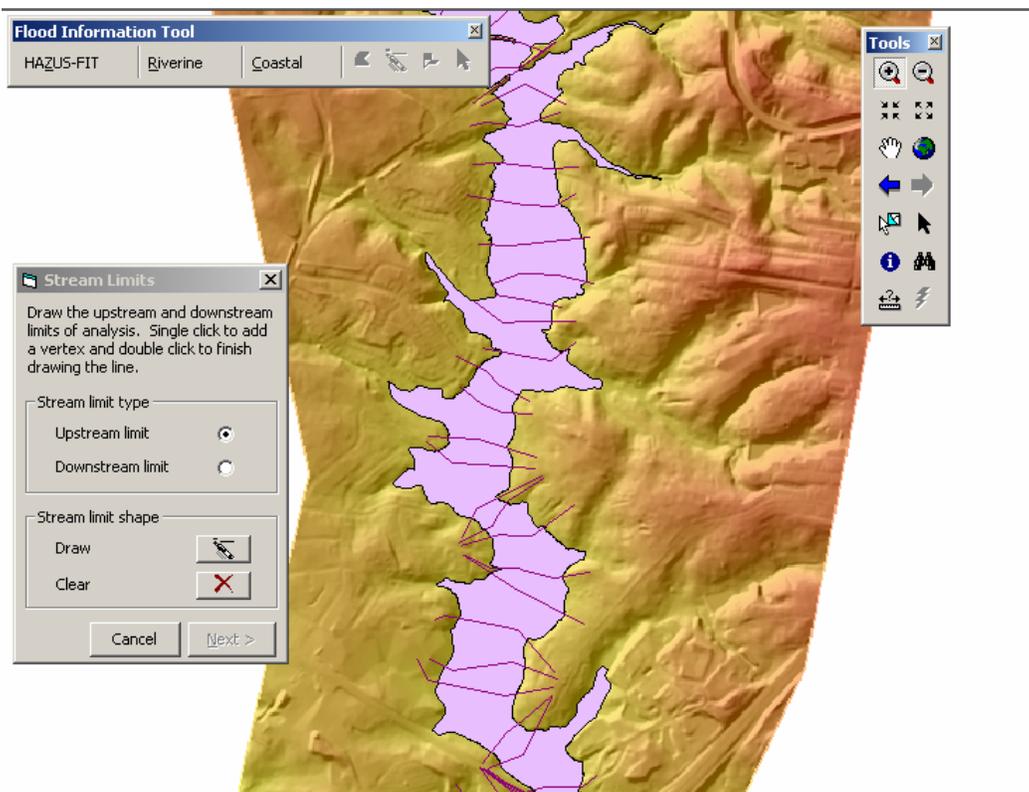
The **Depth Grid Wizard** provides the interface necessary for the user to manipulate their data and produce the initial depth grids by identifying the upstream and down stream limits of the study area, defining the flow centerline buffer and mapping the elevation field and discharge field with the appropriate return period.



The floodplain boundary layer (polygon), the cross-section/elevation layer (attributed polylines), and the DEM (grid) identified in the *Project Setup and Validation dialog* must be in the active dataframe.

⇒ Click on **Riverine** on the *Flood Information Tool* and select **Depth Grid Wizard...**

*The Stream Limits dialog is displayed as shown in Figure 2-13.*



**Figure 2-13: Stream Limits Dialog**

The *Stream Limits dialog* is used to identify the upstream and downstream limits of the study area.

⇒ Select the **Upstream limit** radio button for the Upstream limit.

*The Draw Polyline tool in the Draw limits group box is enabled.*

⇒ Click on the **Draw** button.

*The cursor changes from an arrow to a crosshair when held over the active map, indicating that the draw polyline tool is active. This tool is used to cut the floodplain polygon into a subset used for subsequent analyses.*

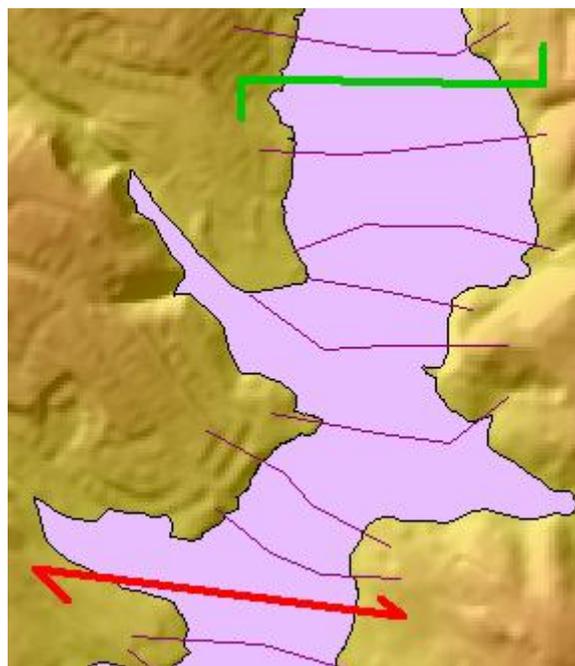
⇒ To draw the stream limits on the active map, single click to add a vertex and finish by double clicking on the map.

When drawing the stream limits, there are several issues to keep in mind:

- Each stream limit line should cross the floodplain boundary, intersecting its perimeter exactly twice.
- No stream limit line should intersect a flood elevation line.

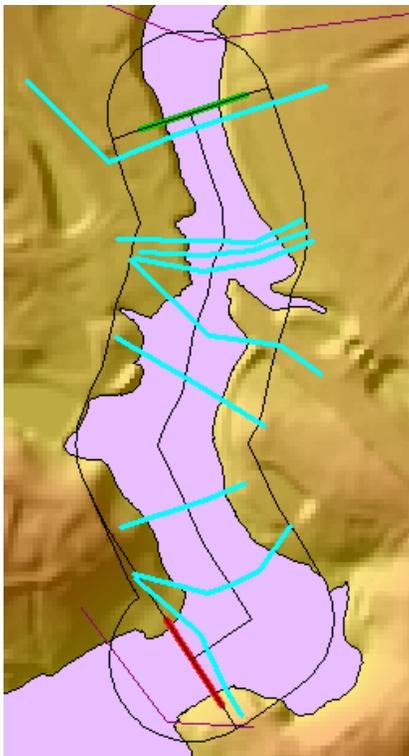
- The shape of the limit should mimic that of the adjacent flood elevation line to be included in the analysis. For example, the orientation of the upstream limit line should be parallel that of the flood elevation line just downstream.
- The end points of the stream limits should extend at least two cell sizes beyond the floodplain boundary.
- Avoid drawing Stream Limits that look like the ones shown in Figure 2-14.

These Stream Limits are incorrect since they have segments at the end(s) that are perpendicular or that reverse direction.



**Figure 2-14: Unacceptable Stream Limits**

*The FIT checks to ensure that lines drawn by the user cross the floodplain polygon exactly twice before saving the polyline. This prevents the user from stopping the line within the floodplain and from crossing the polygon in several places.*



The upstream limit is OK in this example since the upstream limit extended to the outer edge of the flow centerline buffer does not intersect the flood elevation line just downstream. However, if the flow centerline buffer had been larger, the upstream limit may have intersected the flood elevation line and caused an error.

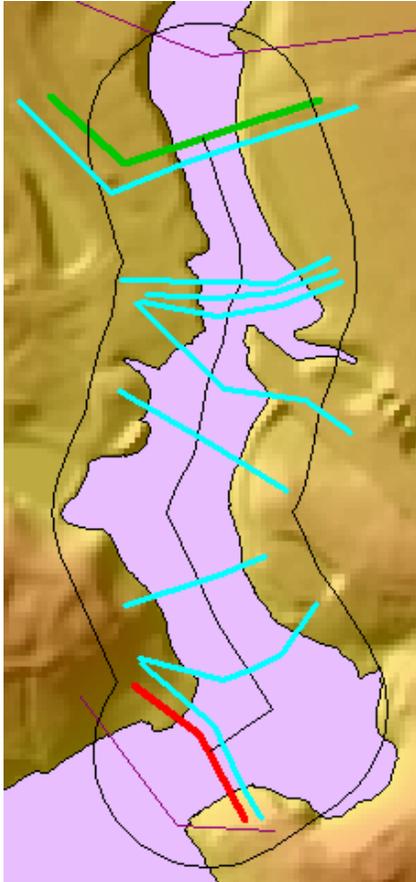
The error, similar to the one shown in Figure 2-16, occurred since the downstream limit, extended to the edge of the flow centerline buffer, has intersected the flood elevation line just upstream.

Figure 2-17 shows stream limits drawn correctly to avoid an error regardless of the size of the flow centerline buffer.

**Figure 2-15: Incorrect Stream Limits**



**Figure 2-16: Incorrect Stream Limits Error Message**



The orientation of the upstream limit line parallels that of the flood elevation line just downstream, which eliminates the possibility of the two intersecting regardless of the size of the flow centerline buffer.

The orientation of the downstream limit line parallels that of the flood elevation line just upstream, which eliminates the possibility of the two intersecting regardless of the size of the flow centerline buffer.

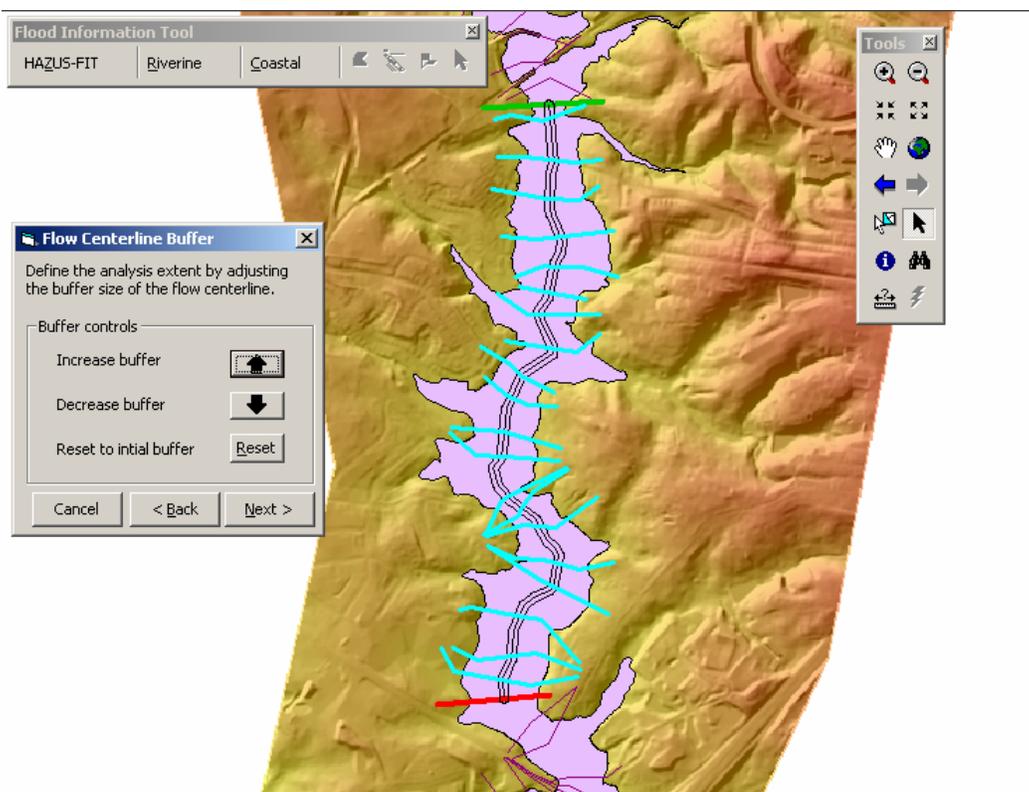
**Figure 2-17: Stream Limits Drawn Correctly**

- ⇒ Repeat this process for Downstream limits.
- ⇒ Click **Next**.

The **FIT** uses the Upstream limit and the Downstream limit to cut the polygon into two polylines representing the left and right sides of the floodplain boundary. The midpoint between the two sides of the floodplain boundary trace out the centerline of general flow. The centerline of the floodplain boundary and a buffer of the centerline are displayed on the DEM (grid). Also, the flood elevation lines that intersect the centerline are highlighted, indicating which lines will be used in the depth grid computations. The Flow Centerline Buffer dialog is displayed on top of the active window as shown in Figure 2-18.



The processing time required to determine the flow centerline can markedly increase for input floodplain polygons with very narrow sections between the upstream and downstream limits. This is because the midpoint of the floodplain boundary cannot be calculated if the floodplain width is less than twice the DEM cell size. As a remedy, the **FIT** buffers the floodplain boundary polygon, a process that can consume several minutes depending on the size of the polygon and number of vertices.



**Figure 2-18: Flow Centerline Buffer Dialog**

The centerline buffer is used to define the universe in which flood hazard computations will take place. The buffer controls are used to adjust the estimated floodplain width of the lowest frequency flood to be analyzed. Ideally, the centerline buffer should include all areas through which floodwaters are conveyed. Within the conveyance boundary, the **FIT** will calculate flood elevations by interpolating between adjacent sets of cross-sections. In non-conveyance areas (backwater), flood elevations should be based on the elevation at which water backs up from the channel rather than through interpolation between cross-sections. As such, non-conveyance areas should not be included in the flow centerline buffer. Instead non-conveyance areas (ponding) can be added later in the **FIT** through backwater analysis.

- ⇒ Click the **Increase buffer** button to increase the buffer by one step. Continue as needed.
- ⇒ Click the **Decrease buffer** button to decrease the buffer by one step. Continue as needed.
- ⇒ Use the **Reset** button to return to the buffer size that existed upon entering this dialog.
- ⇒ If you need to return to the *Stream Limits dialog*, click the **Back** button.
- ⇒ Click **Next**.



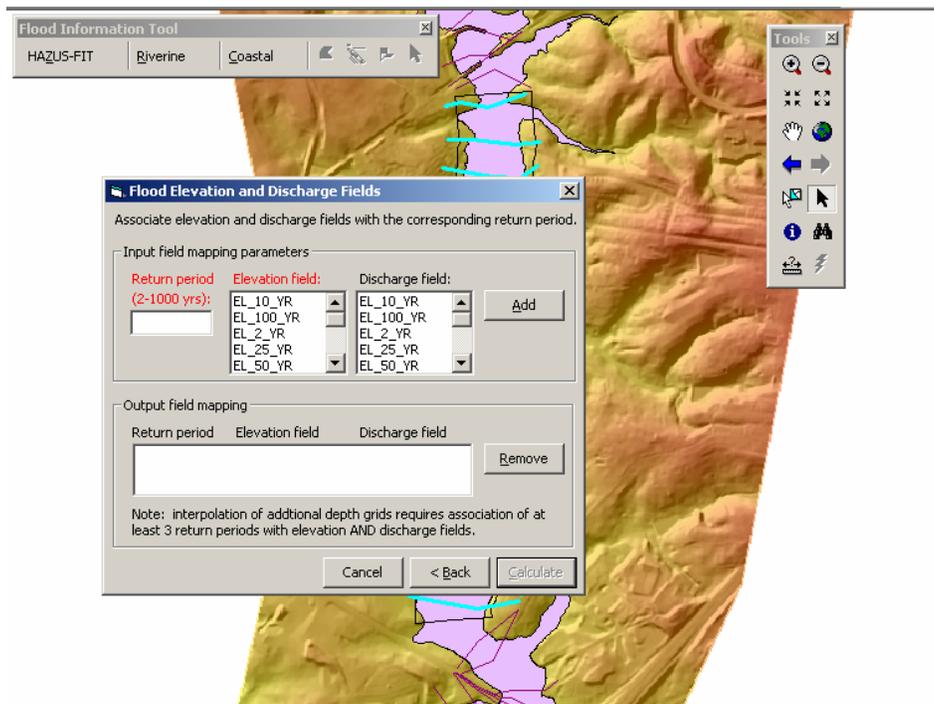
If necessary, the upstream and downstream limit lines are extended to the edges of the centerline buffer. The limits are extended with the orientation at their endpoints. An error message is posted if the extended limits intersect a flood elevation line. If this occurs, the

limit geometry and/or buffer size will need to be altered.

*The Flood Elevation and Discharge Fields dialog is displayed on top of the active map as shown in the Figure 2-19. The FIT cannot predict which attribute fields of the user supplied flood elevation polyline shapefile are used to store the flood elevation and discharge data. This dialog allows you to point the FIT to the attribute fields holding the flood elevation and discharge information for your flood return periods.*



In most cases, specifying an incorrect field will not cause the analysis to stop, but will definitely produce inaccurate results.



**Figure 2-19: Flood Elevation and Discharge Fields Dialog**

- ⇒ Type the return period to be mapped in the **Return period (2-500 yrs)** text box. This is the return period that you would like to map to the elevation field from your attribute database.

Sample data: Input **X** (where X is the value of the return period).

- ⇒ Select the flood elevation field from the **Elevation field** list box to link the return period to a particular elevation field. This list box contains the numeric fields from the attribute table of the flood elevation lines shapefile.

Sample data: Select **EL\_X\_YR** (where X is the value of the return period).

- ⇒ Select the discharge field from the **Discharge field** list box to link the return period to a particular discharge field. This list box also contains the numeric fields from the attribute table of the flood elevation lines shapefile. Associating a discharge field with the return period and flood elevation field is optional.

Sample data: Select **Q\_X\_YR** (where X is the value of the return period).

*When a return period has been entered and a flood elevation field have been selected, the Add button is enabled.*

- ⇒ Click **Add** to link the return period with the selected Elevation field and Discharge field.

*The Return period, Elevation field name, and Discharge field name, if selected are added to the Output field mapping text box in the lower portion of the dialog. The selected elevation field and discharge field are removed from the Elevation field and Discharge field list boxes in the Input field mapping parameters group box.*

- ⇒ Repeat as needed to analyze additional return periods.



At least 3 return periods with elevation AND discharge values are required for the interpolation of additional depth grids and to enable the *Riverine* menu item, **Interpolate New Depth Grid**.

- ⇒ To remove a return period and its associated elevation and discharge fields from the display text box, select a line and click **Remove**.

*The selected record is deleted from the defined return period list box in the lower portion of the dialog and the elevation and discharge fields used for the deleted record are once again available in the Elevation field and the Discharge field list boxes.*

- ⇒ To return to the *Flow Centerline Buffer* dialog, click **Back**.

*When at least one field-mapping record is added to the lower text display box, the Calculate button is enabled.*

- ⇒ Click **Calculate**.

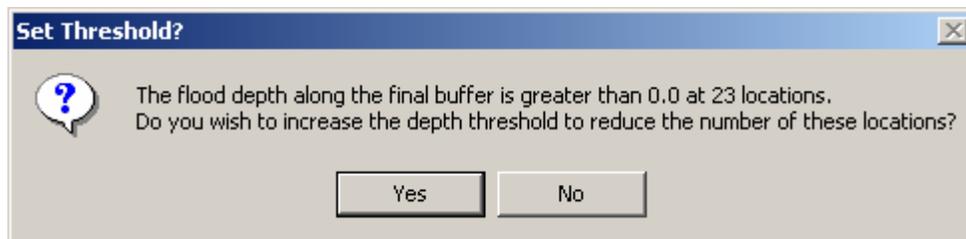
*Calculation of the flood elevation and depth grids for all return periods entered now begins.*

*The duration of analysis depends primarily upon the size of the final buffer, the cell size of the DEM, and the computer hardware configuration. As with other dialogs in the **FIT**, computation progress is displayed in the title bar in the upper left-hand corner of the screen. Upon completion of the computations, the Flood Elevation and Discharge Fields dialog is closed. The Backwater Analysis option on the Riverine menu is enabled.*

At this point, up to 2 additional layers are added to the map.

- 1    *Depth X*        This map layer shows the depth grid for return period X, where X represents the lowest frequency flood analyzed. If multiple return periods were analyzed, the associated depth grids are saved to the working directory but only the grid for return period X is added to the map.
  
- 2    *Boundary X*      This map layer shows the floodplain boundary for return period X, where X represents the lowest frequency flood analyzed. If multiple return periods were analyzed, the associated floodplain boundaries are saved to the working directory, but only the boundary for return period X is added to the map.

The term “backlines” in the FIT refers to locations along the final buffer at which the depth of flooding exceeds zero. If the analysis determines that there are more than 10 backlines, the Set Threshold? dialog, shown in Figure 2-20, is displayed.



**Figure 2-20: Set Threshold? Dialog**

The term “depth threshold” refers to the depth of flooding at the edges of the floodplain boundary that are significant enough that they should be highlighted to the user.

At this point, you may want to consider the following options:

Increase the centerline buffer.

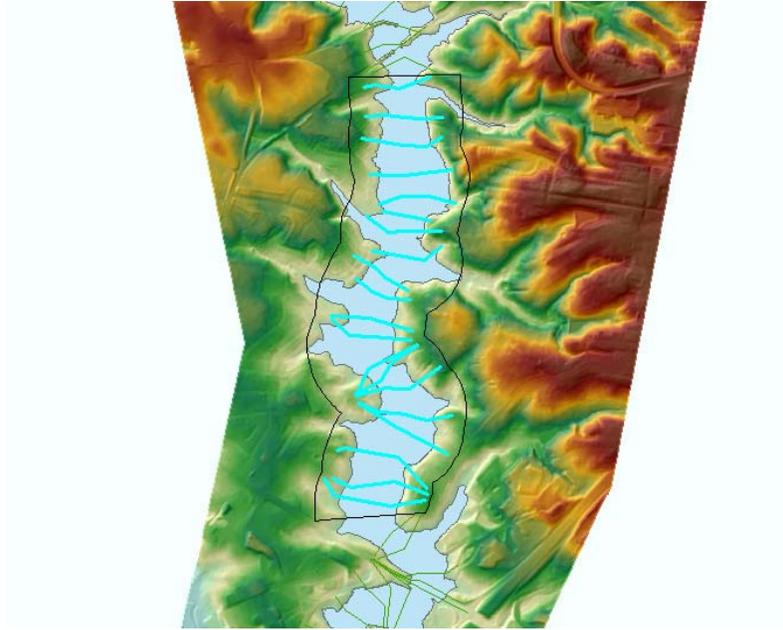
⇒ Click **No** on the *Set Threshold? dialog*.

*If backlines occur where flow is conveyed, then the final buffer was too narrow.*

⇒ Increase the centerline buffer by rerunning the **Depth Wizard** as described in this section and increase the centerline buffer as shown in *Figure 2-21*.



- When the **Depth Wizard** is repeated for an area, the data is overwritten.
- Increasing the centerline buffer can actually increase the number of backlines. This can occur when a long backline is broken up into several backlines.

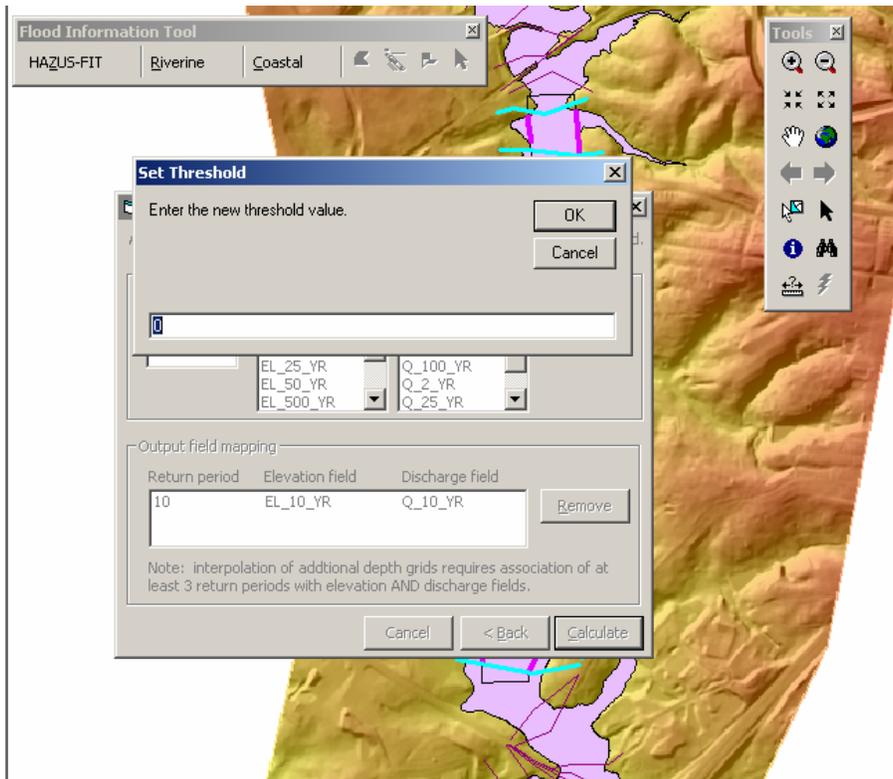


***Figure 2-21: Example of Increased Centerline Buffer***

Increase the depth threshold.

⇒ Click **Yes** on the *Set Threshold?* dialog.

The *Set Threshold* dialog, shown in Figure 2-22, is displayed for a new threshold value to be entered. The FIT uses a value of 0 ft as the default threshold; depths greater than 0 ft at the edges of the floodplain boundary will be highlighted to the user as potential backwater areas. The user can reset this threshold to >0 ft to allow for uncertainty in the DEM; the areas below the newly set threshold will be excluded from the potential backwater areas that will be shown to the user.



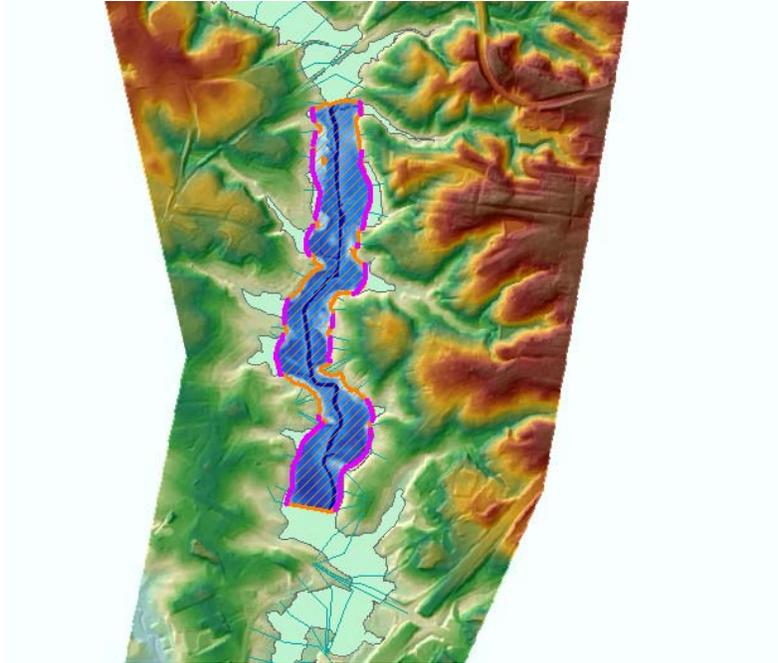
**Figure 2-22: Set Threshold Dialog**

⇒ Click **OK**.

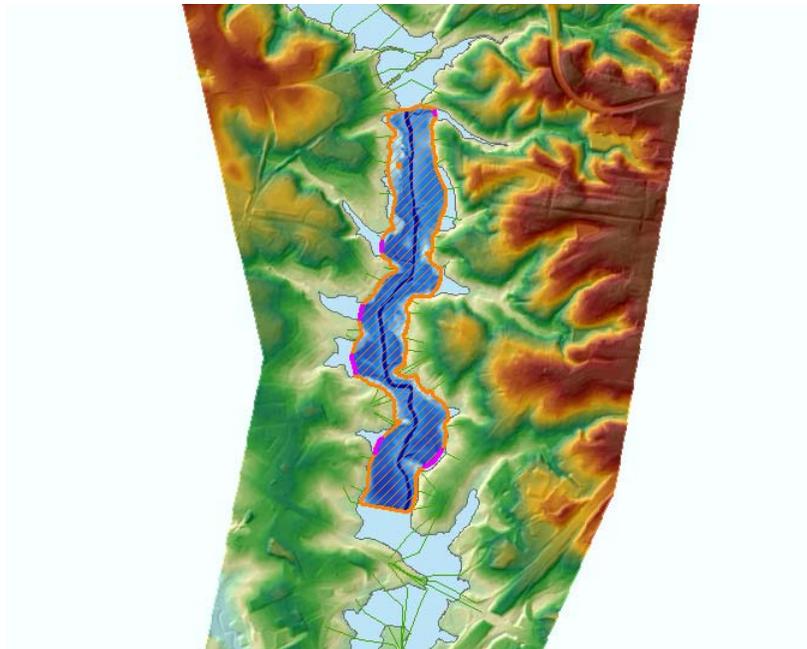
The backlines are recalculated, as shown in Figure 2-24.



Setting a new value for the threshold does not change the flood elevation, flood depth grid or the floodplain boundary.



**Figure 2-23: Example of Backlines with Default Threshold**



**Figure 2-24: Example of Recalculated Backlines after Setting Threshold to 3 ft**

Leave as is and continue.

*If the backlines occur where flow is not conveyed, then they indicate potential backwater (non-conveyance) areas of flooding.*

⇒ Click **No** and continue to Backwater Analysis Menu, Section 2.4.2.



It is recommended that the user save the file before proceeding to the next menu option.

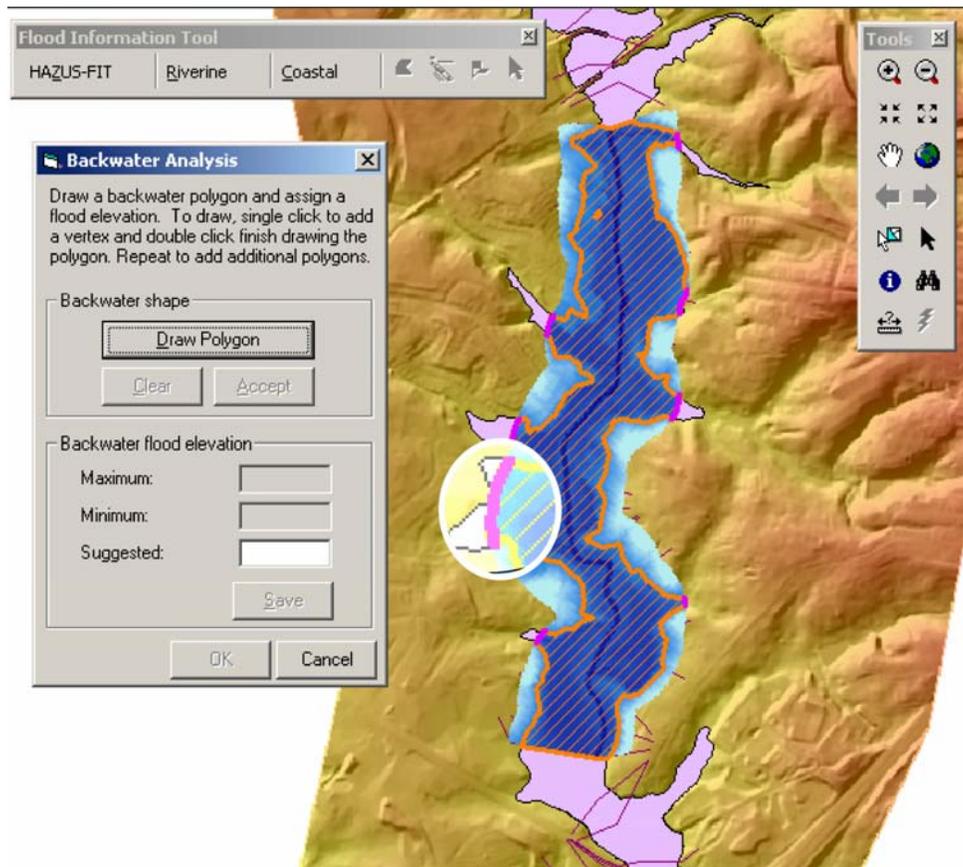
⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

## 2.4.2 Backwater Analysis Menu

The **Backwater Analysis** option on the **Riverine** menu allows the user to perform map operations to identify and establish flood elevations for non-conveyance areas (ponds) of flooding. Lines along the edge of the bounding polygon where the flood depths are greater than zero have been identified by the **FIT** and are shown on the display in magenta as a shapefile called “Backlines”. (See magnified item on Figure 2-25.)

- ⇒ Click **Riverine** on the *Flood Information Tool* toolbar and select **Backwater Analysis** from the **Riverine** menu.

*The Backwater Analysis dialog, shown in Figure 2-25, is displayed.*



**Figure 2-25: Backwater Polygons Dialog – Initial**

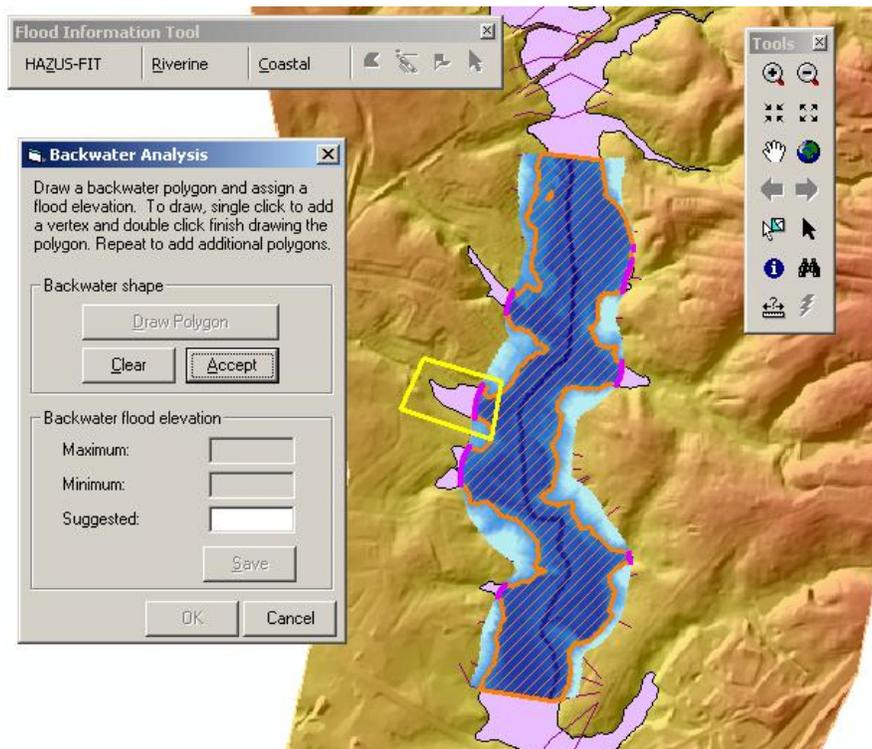
- ⇒ Click on the **Draw Polygon** button to activate the backwater polygon drawing tool.

- ⇒ Draw a polygon on the active map layer delineating an area of ponded water. The polygon should extend into the depth grid far enough to capture non-conveyance areas, and outside the grid to a sufficient degree to capture the extent of flooding. The backwater polygon must intersect the floodplain boundary of the lowest frequency flood analyzed. Click to add each vertex and double click to finish drawing the polygon.



Values from the flood elevation grid will be superceded wherever the backwater polygon(s) exist.

*With a Backwater Polygon drawn, you have the option to accept the polygon or to clear the just drawn polygon.*



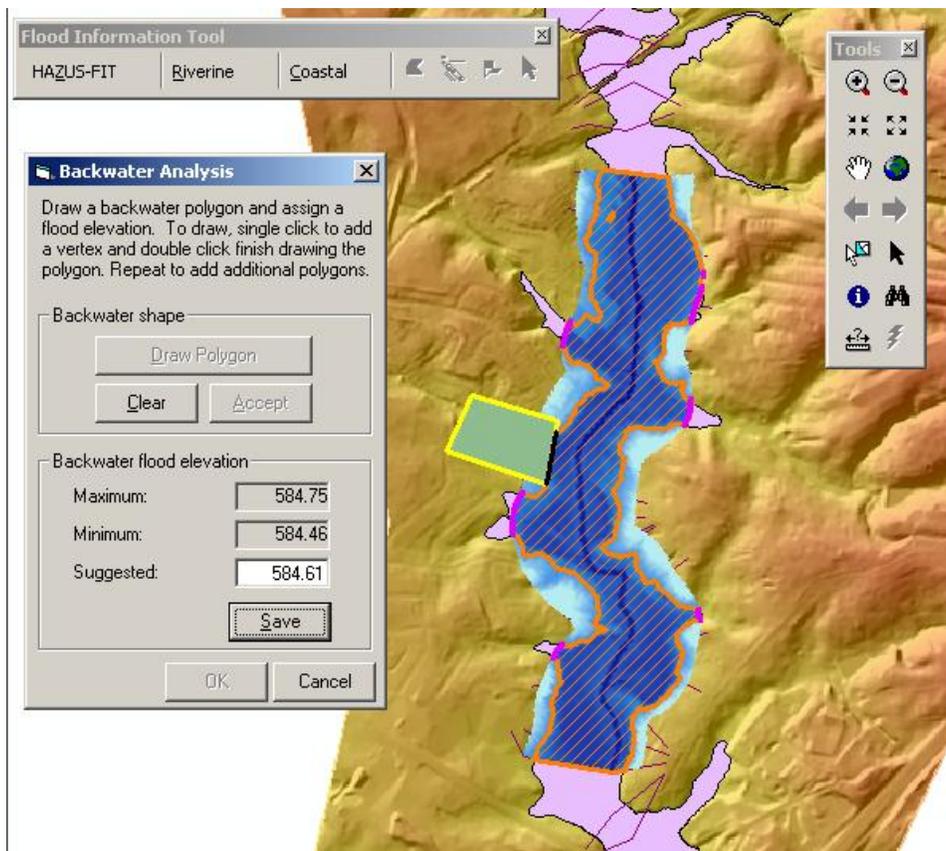
**Figure 2-26: Backwater Polygon Dialog - Clear or Accept**

- ⇒ Upon completion of your backwater polygon, click on the **Accept** button. Use **Clear** to erase the polygon and start again.

*An algorithm is launched to identify the maximum and minimum flood elevations along the intersection of the backwater polygon boundary and the flood elevation grid of the lowest frequency flood analyzed. The length of intersection is featured on the map in black.*

*Upon completion of the algorithms, the Backwater Polygons dialog as seen in Figure 2-27 is displayed with the Maximum (flood elevation) and the Minimum (flood elevation) displayed in un-editable text boxes. The average of those flood elevations is displayed as a default suggestion in the Suggested text box.*

- ⇒ Use the suggested elevation or enter a value.
- ⇒ Click the **Save** button to commit the backwater shape and elevation to disk.



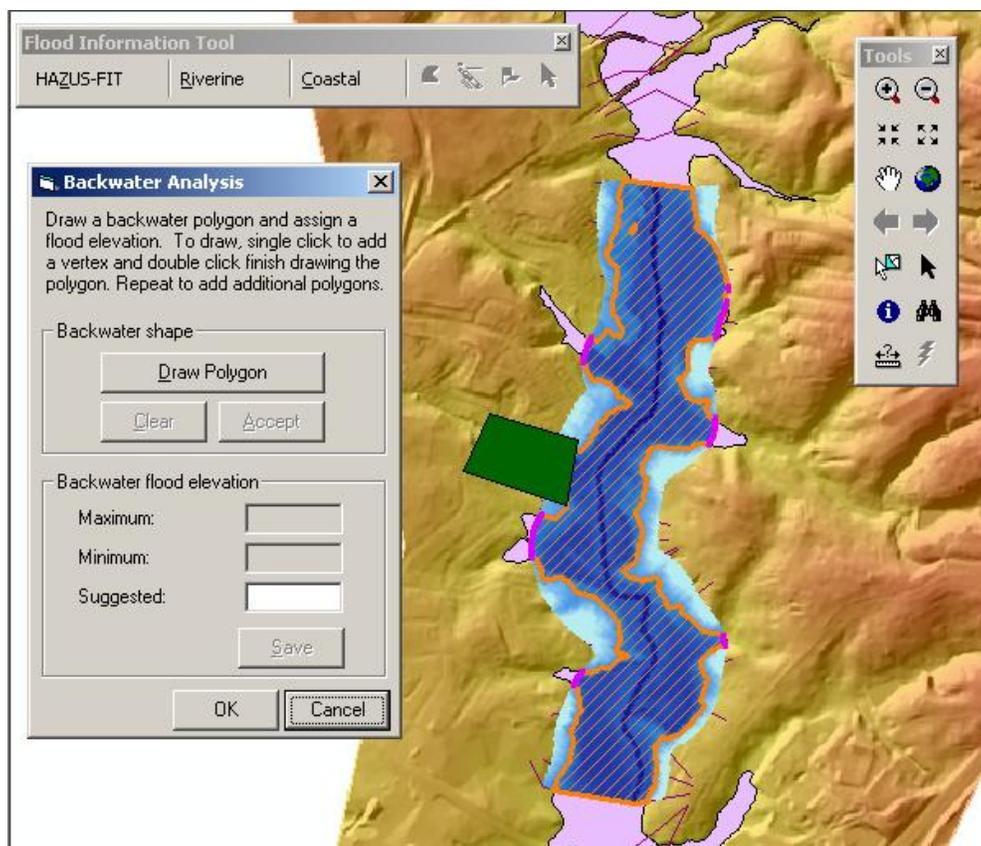
**Figure 2-27: Backwater Polygon Dialog - With Backwater Flood Elevation Information**



Once the input values have been saved, they cannot be removed by clicking **Cancel**.

*The polygon coverage representing the flood extent is created. The Backwater Polygons dialog is redisplayed as shown in Figure 2-28. (Note: The backwater polygon which is normally displayed in light blue is shown as red due to print considerations.)*

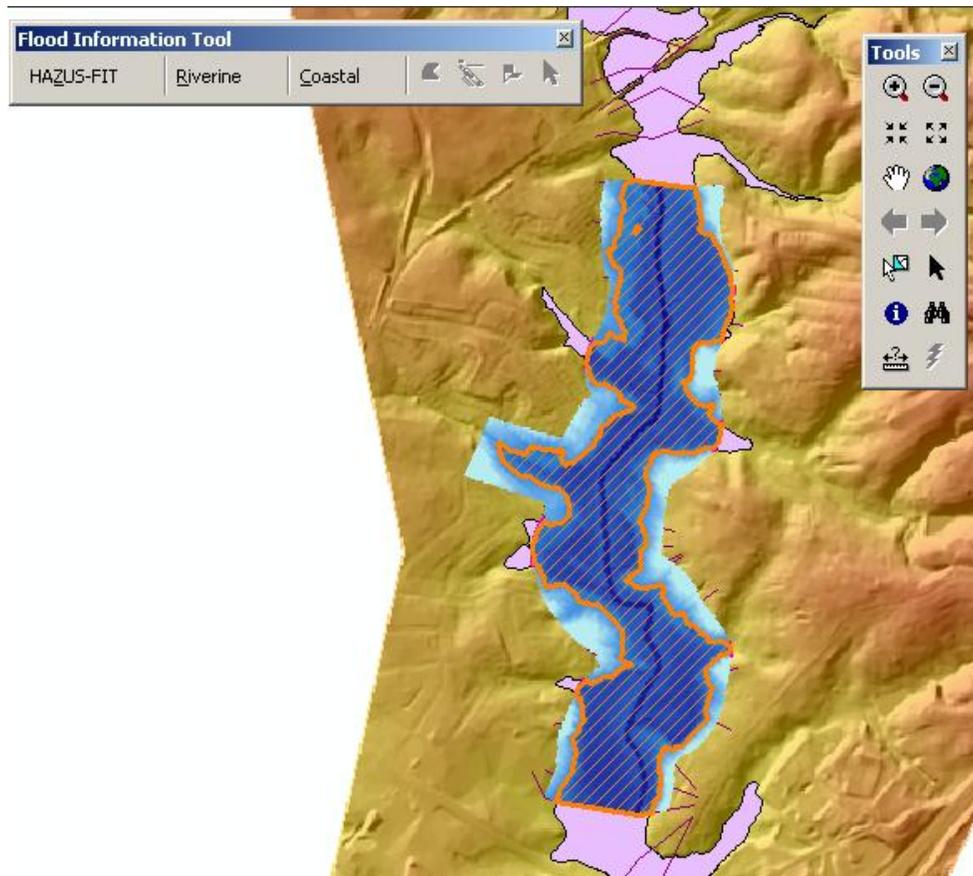
- ⇒ To create another backwater polygon on the map layer repeat the above steps.



**Figure 2-28: Backwater Polygons Dialog - Finish**

⇒ Select **OK** to close the *Backwater Polygon* dialog.

*Upon completion of the calculations, the flood depth grid has been expanded to include the defined backwater polygons and is displayed as shown in Figure 2-29.*



**Figure 2-29: Study Area after Backwater Analysis**



It is recommended that the user save the file before proceeding to the next menu option.

⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

### 2.4.3 Interpolate New Depth Grid

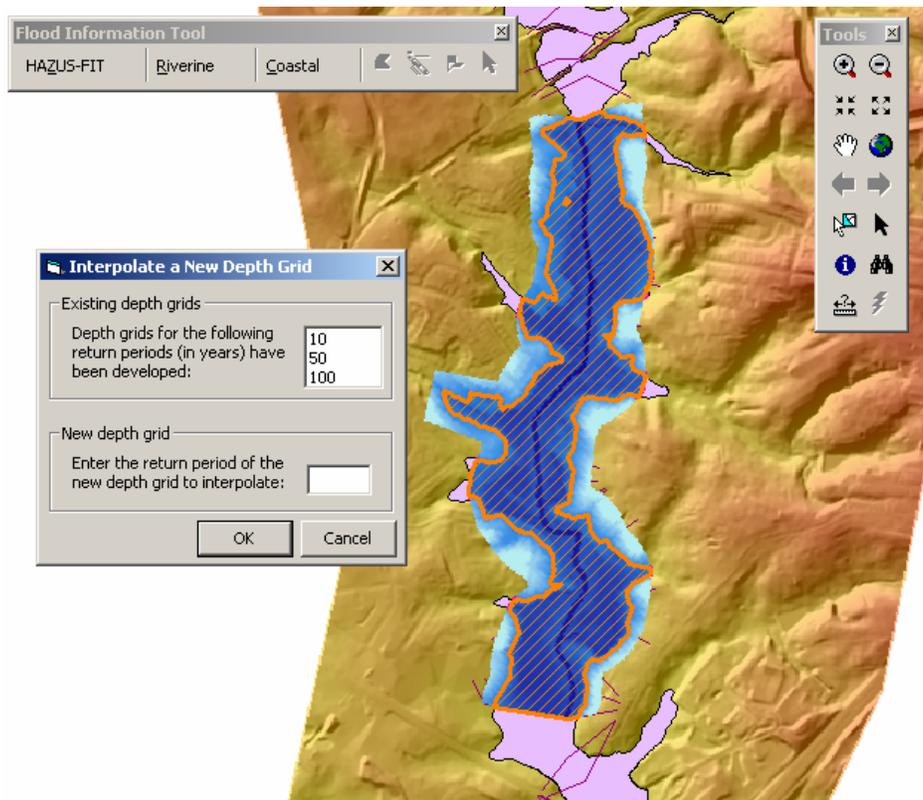
The **Interpolate a New Depth Grid** option on the **Riverine** menu interpolates and creates additional depth grids for user defined return periods between 2 years and 500 years. This option is enabled after the **Depth Grid Wizard** has been completed.

- ⇒ Click **Riverine** on the *Flood Information Tool* toolbar and select **Interpolate a New Depth Grid** from the **Riverine** menu.



At least 3 return periods with elevation AND discharge values must be added on the *Flood Elevation and Discharge Fields* dialog, Figure 2-19, for the interpolation of additional depth grids.

*The Interpolate a New Depth Grid dialog, shown in Figure 2-30, is displayed.*



**Figure 2-30: Interpolate a New Depth Grid Dialog**

*The dialog displays existing depth grids in the **Existing depth grids** group text box. These values are not editable.*

- ⇒ Enter a new return period for the new depth grid in the **New depth grid** group text box.
- ⇒ Click **OK**.
- ⇒ Repeat these steps for each return period for which to interpolate flood hazard grids.



It is recommended that the user save the file before proceeding to the next menu option.

- ⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

## 2.5 Coastal Analysis

The **Coastal** menu options on the *Flood Information Tool* toolbar are available when a coastal hazard project has been selected and validated on the *Project Setup and Validation dialog* shown in Figure 2-4. See Section 2.2.3 for a brief description of each **Coastal** menu option and when it is available.



It is recommended that the user review the Coastal **FIT** Methodology discussion in Section 1.4. This review will help the user anticipate the actions requested by the **FIT** and the resulting actions taken by the **FIT**.



In coastal analyses, unlike riverine, flooding can occur in areas where pre-flood ground elevations lie above the flood surface. Erosion of the frontal dune caused by the flood can lower ground elevations below the flood surface. The flood-induced erosion analysis accounts for erosion caused by the flood. Functionality to analyze long-term shoreline erosion is not included in the **FIT**, but is included in *HAZUS*.



The FIT's title bar offers updates to the user on which process is currently being handled during periods of data review, analyses, etc.

## 2.5.1 Build 100-Yr Elevation Grid

The **FIT** cannot predict which attribute fields of the user supplied flood elevation polygon shapefile are used to store the base flood elevations and FEMA flood hazard zones of the 100-year flood.

FEMA flood hazard zone names recognized by the **FIT** are:

**Table 2-5:**  
**FEMA Flood Hazard Zone Names and Descriptions Recognized by the FIT**

Flood Hazard Zone Name	Description
A	Flood Insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. No Base Flood Elevations (BFE) are provided.
AE	Flood Insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study (FIS) by detailed methods. Base Flood Elevations (BFE) are provided.
AO	Flood insurance rate zone that corresponds to the areas at 100-year shallow flooding (usually sheet flow or sloping terrain) where average depths are between 1 and 3 feet. BFEs are not provided but base flood depths are provided.
V	Flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with waves. Approximate methods are used so no BFEs are provided.
VE	Flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with waves. Detailed methods are used and BFEs are provided.
VO	Flood insurance rate zones that correspond to the areas of 100-year coastal shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet, and that have additional hazards associated with waves. BFEs are not provided but base flood depths are provided.
X	Flood insurance rate zones that correspond to areas outside 100-year floodplains, areas of 100-year sheet flow flooding where average depths are less than 1 foot. No BFEs are provided.



Users must attribute numbered A zones (e.g., A1 through A30, A99, etc.) as AE zones for the FIT to recognize and use them. Similarly, there is a requirement to attribute numbered V zones (e.g., V1 through V30, V99, etc.) as VE zones. B and C zones should be attributed as Zone X

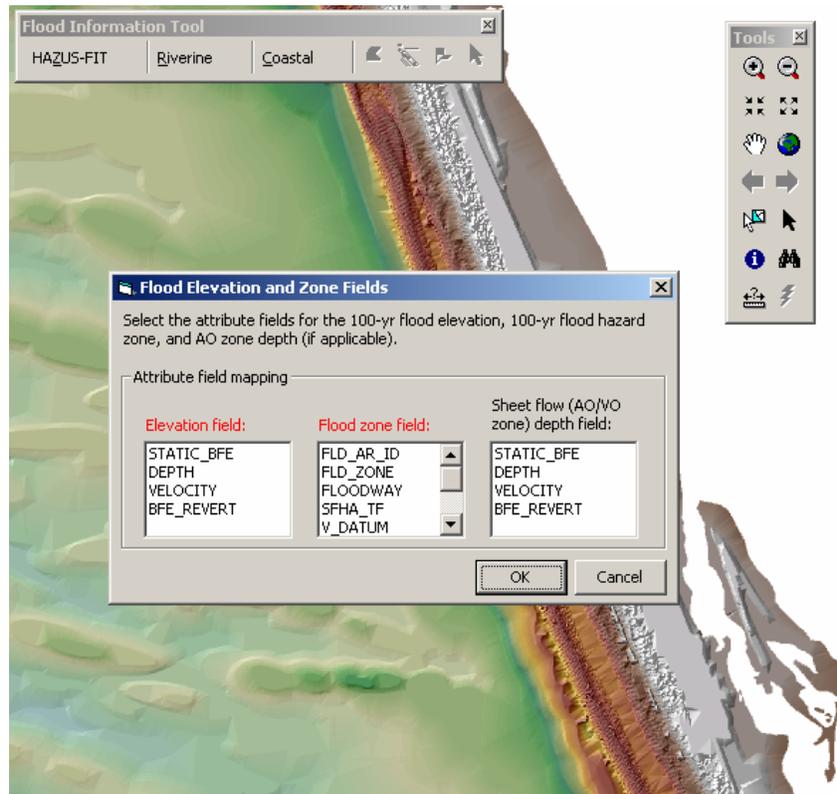
The **Build 100-Yr Elevation Grid** menu option on the **Coastal** menu asks the user to define the attribute fields for flood elevation and hazard zone of the 100 year flood and creates the 100-year elevation grid based on the selected fields.



In some cases specifying incorrect fields will not cause the analysis to stop but will definitely produce inaccurate results.

- ⇒ Click on **Coastal** on the *Flood Information Tool* toolbar and select the **Build 100-Yr Elevation Grid...** menu option.

*The Flood Elevation and Zone Fields dialog is displayed as shown in Figure 2-31.*



**Figure 2-31: Flood Elevation and Zone Fields Dialog**

- ⇒ Select the attribute field which has the flood elevation data from the **Elevation field** list box. (Required)

Sample data: Select **STATIC\_BFE**.

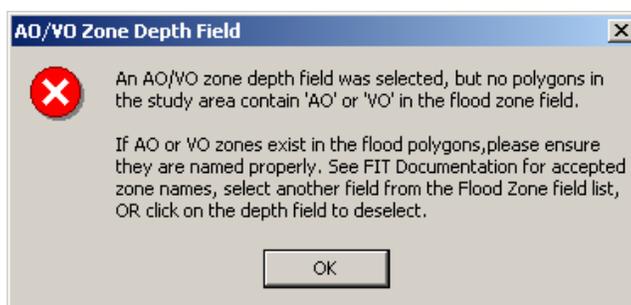
- ⇒ Select the attribute field which has the flood zone data from the **Flood zone field** list box. (Required)

Sample data: Select **FLD\_ZONE**.

- ⇒ If the data contains AO/VO zones, you should select the attribute field which has the depth data from the **Sheet flow (AO/VO zone) depth field** list box. (Optional)

Sample data: Leave empty (If user selects one of the fields, the following error will appear).

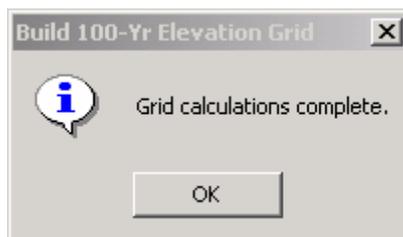
*The FIT reviews the information in the selected fields. The FIT notifies the user if problematic data is found as shown in Figure 2-32 when a field has been selected in the **Sheet flow (AO/VO zone) depth grid field** group box and the data does not contain any AO or VO zones.*



**Figure 2-32: AO/VO Zone Depth Field**

- ⇒ Click **OK** to dismiss the error message.
- ⇒ Review the data and correct the problem.
- ⇒ Click **OK**.

*An analysis is performed based upon the selected flood elevation and zone information and a 100 year elevation grid is created. A message box is displayed to notify the user that the grid calculations are complete.*



**Figure 2-33: Build 100-Yr Elevation Grid Message Box**

- ⇒ Click **OK**.

*The Shoreline Wizard... option is enabled on the Coastal menu.*



It is recommended that the user save the ArcMap document before proceeding to the next menu option.

⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

## 2.5.2 Shoreline Wizard

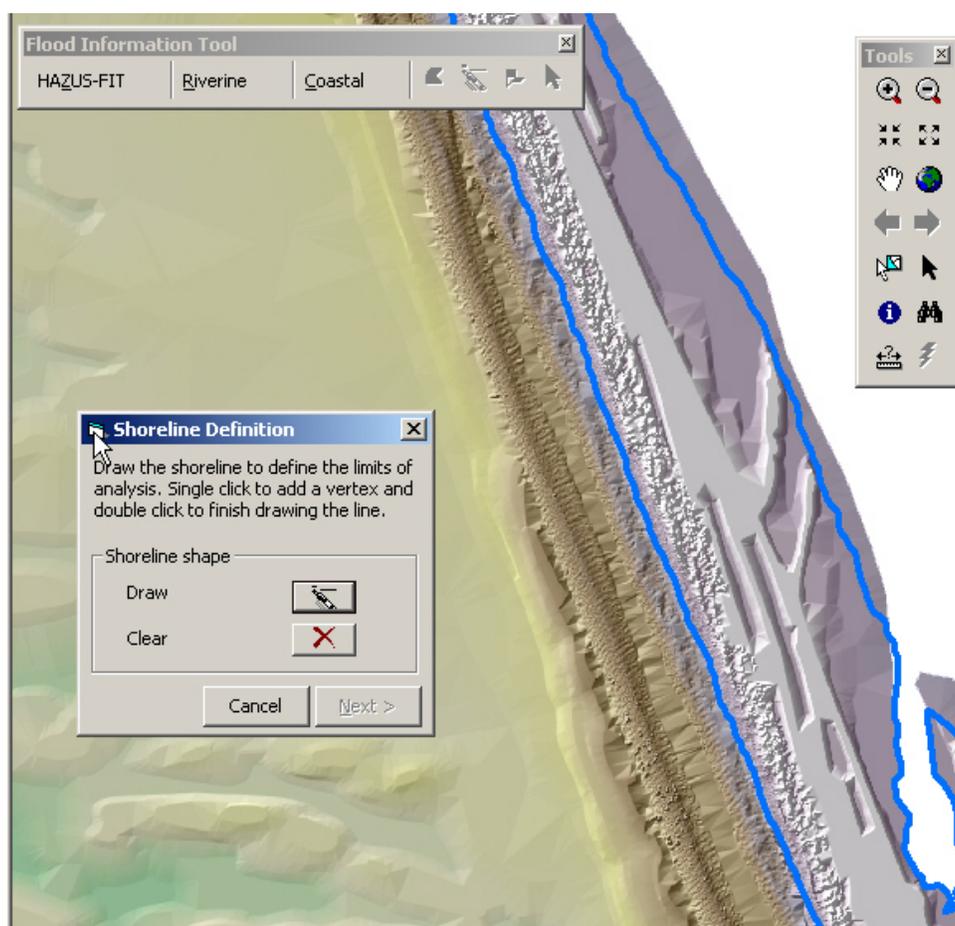
The **Shoreline Wizard** option on the **Coastal** menu launches a series of dialogs designed to help the user identify and characterize the shoreline of interest, the specific shoreline reach of interest, and input shoreline descriptive information.



Some areas are subject to flooding from more than one coastal flood source. For example, a barrier island may be exposed to flooding from the open ocean and a bay. In such cases, the **FIT** Coastal Hazard Process must be completed for each flood source and its associated shoreline.

⇒ Select the **Shoreline Wizard** on the **Coastal** menu.

*The Shoreline Wizard displays the Shoreline Definition dialog designed to allow the user to define the shoreline and the limits of the analysis. See Figure 2-34.*



**Figure 2-34: Shoreline Definition**



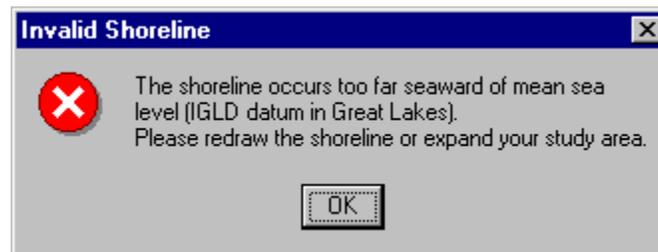
The user should draw the shoreline as a polyline following the general shoreline shape, entirely within the limits of the study area polygon. Also there is a minimum length requirement of 100 feet. On average, the polyline should be drawn at approximately Mean Sea Level in tidal areas and near the IGLD chart datum along the Great Lakes. It is not necessary to follow small-scale changes in shoreline orientation -- in fact, doing so can cause problems during the subsequent transect creation and grid interpolations.



If the shoreline is drawn too far landward, the frontal dune analysis routine may not work; if the shoreline is drawn too far seaward, some or all of the transects that **FIT** constructs on this shoreline will be completely submerged in to the water and an error message will result in the further stages of the Shoreline Wizard (specifically at the end of the *Shoreline Segment Characteristics dialog*, when **Finish** is clicked). Another check that will be performed at this mentioned further stage is making sure each transect has at least 500 ft. of length on the land (above reference elevation). It is a good idea for the user to keep these in mind when drawing the shoreline so that these checks will not fail.

Both the shape of the study area and the relative location of the drawn shoreline can cause these checks to fail. Possible error messages are shown below.

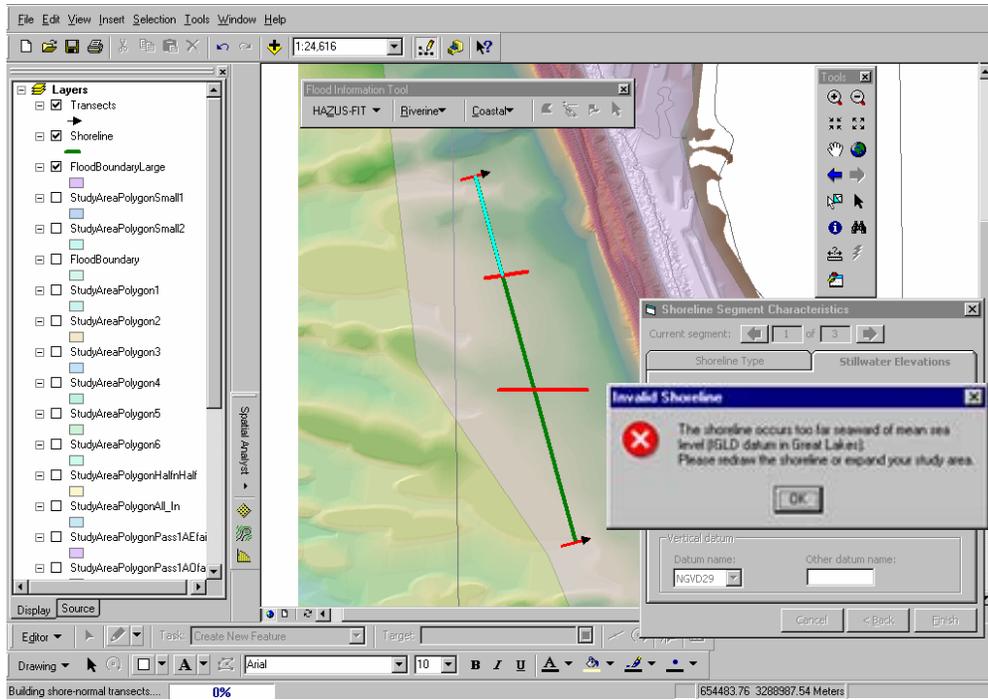
Error message #1:



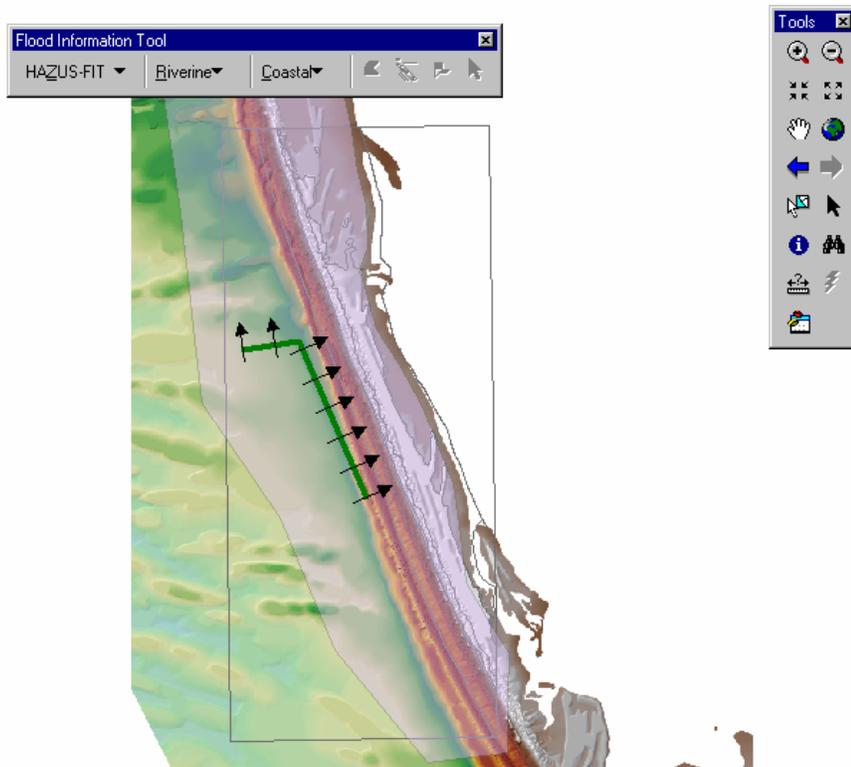
**Figure 2-35: Error Message - Shoreline Occurs Too Far Seaward**

The error message shown in Figure 2-35 has multiple ways of being generated.

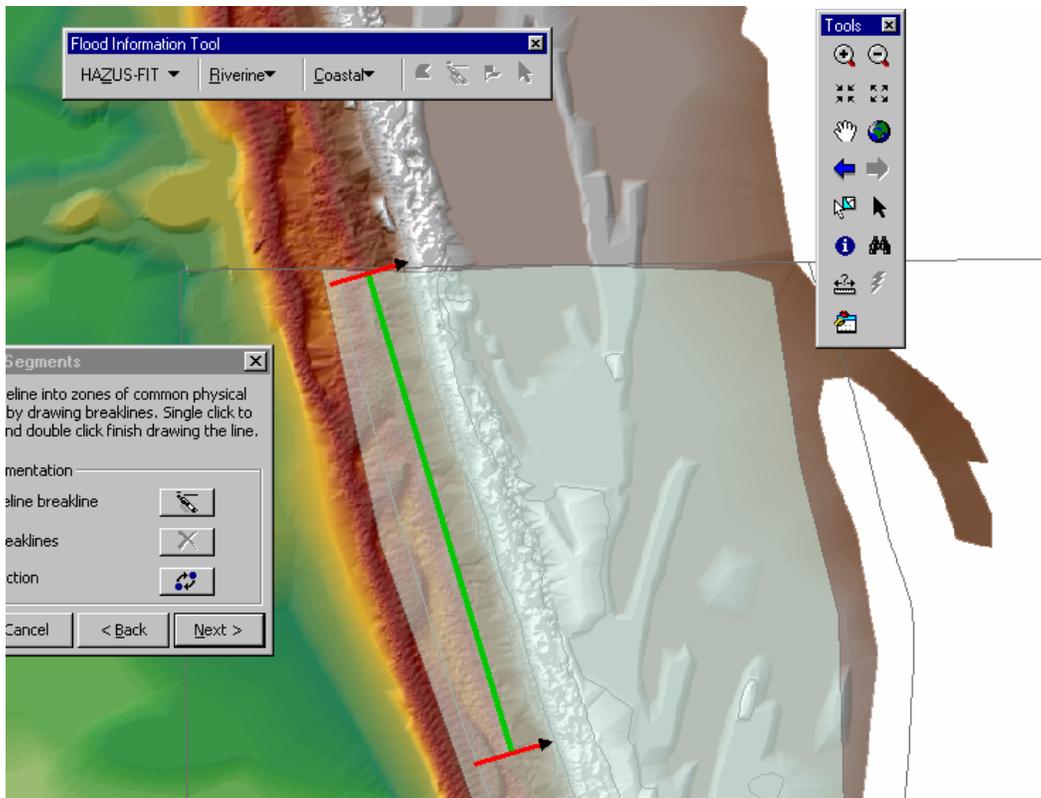
- The user drawn shoreline is too far offshore as shown in Figure 2-36.
- Some of the transects can never reach land because of the way they are oriented. See Figure 2-37.
- The user drawn shoreline is very close to the boundary of the study area as shown in Figure 2-38.



**Figure 2-36: Shoreline - Too Far Offshore**

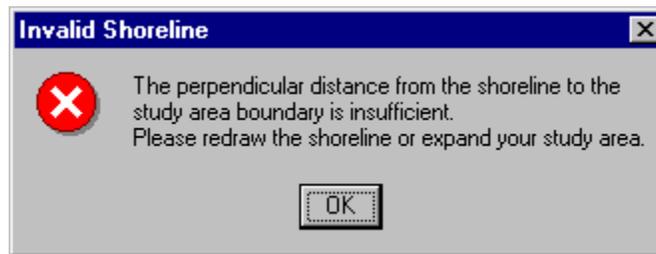


**Figure 2-37: Some Transects Can Never Reach Land**



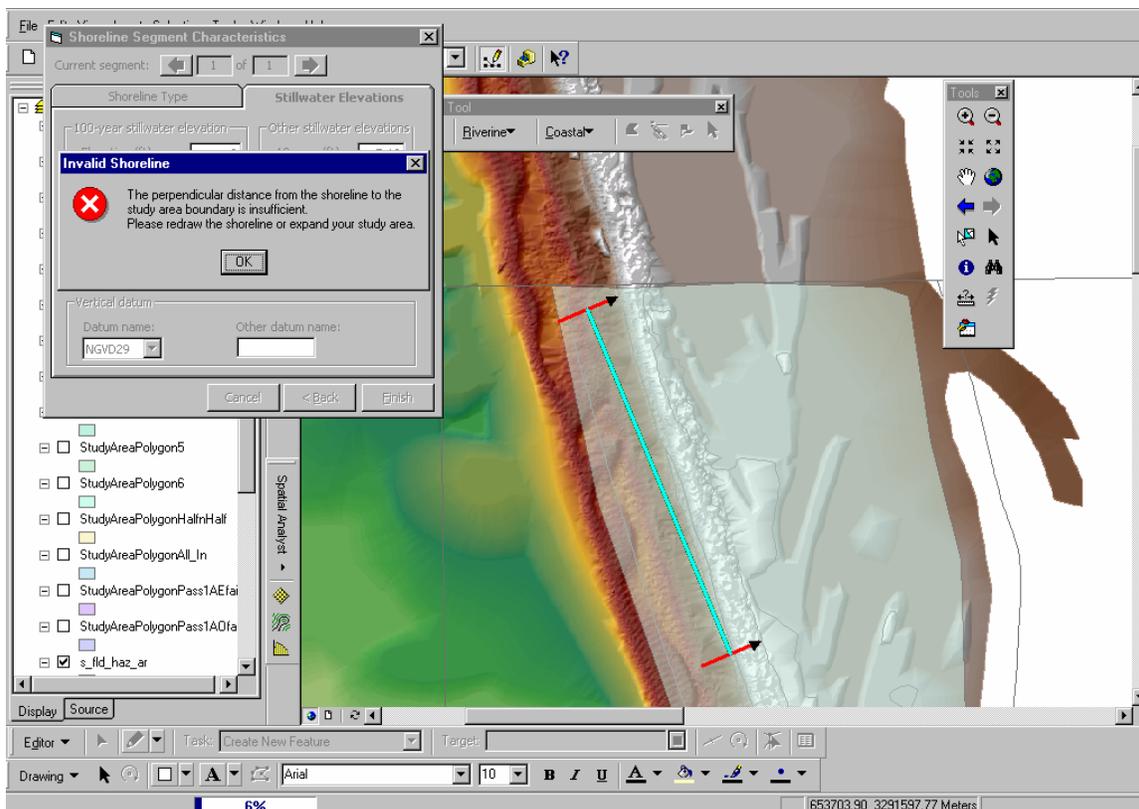
**Figure 2-38: User Drawn Shoreline – Very Close to the Study Area Boundary**

Error message #2:



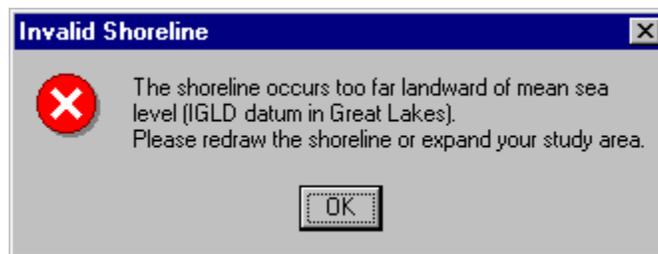
**Figure 2-39: Error Message - Shoreline Very Close to the Study Area Boundary**

When the perpendicular distance from the shoreline to the study area boundary is insufficient as shown in Figure 2-40, the error message shown in Figure 2-39 will be displayed. FIT needs at least 500 ft. long transects to perform analysis.



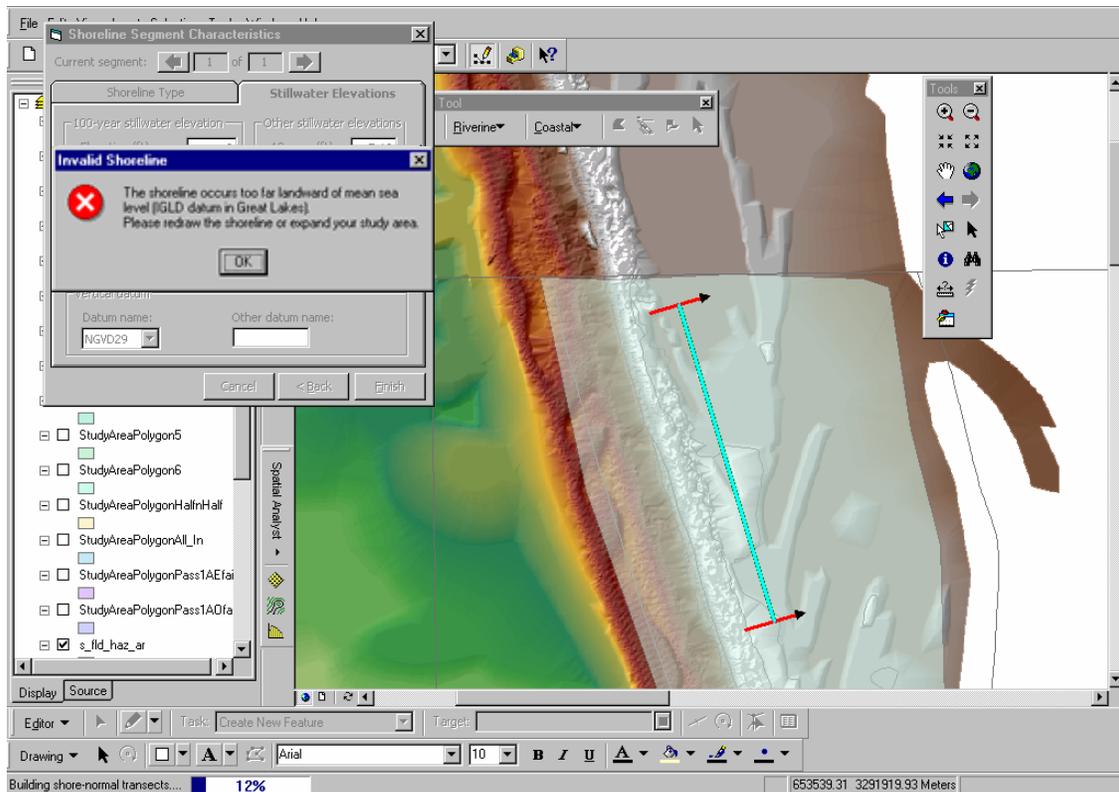
**Figure 2-40: Shoreline Too Close to the Study Area Boundary**

Error message #3:



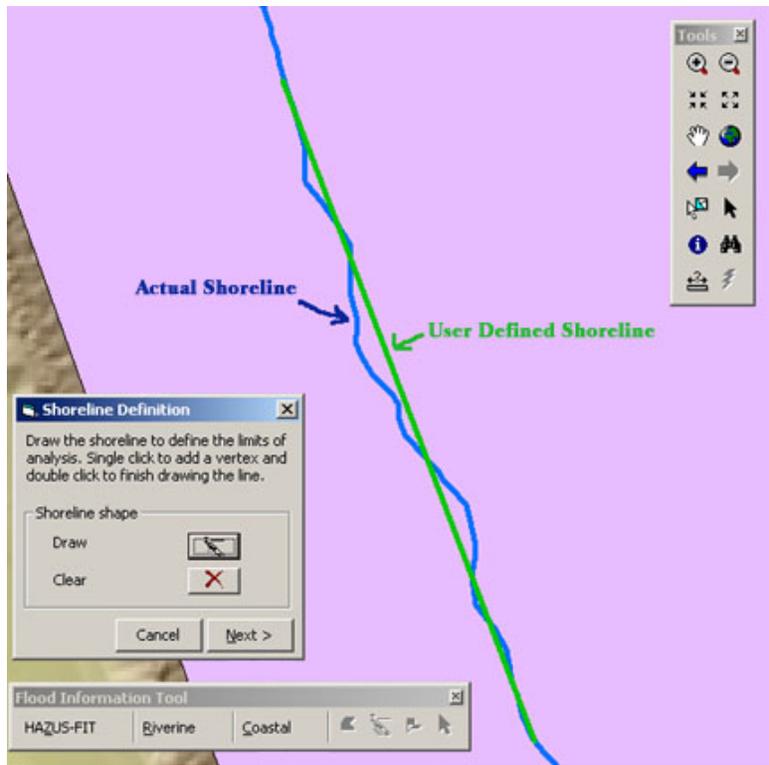
**Figure 2-41: Error Message – Shoreline Too Far On Land**

The error message shown in Figure 2-41 will appear when the user drawn shoreline is drawn too far landward. See Figure 2-42.

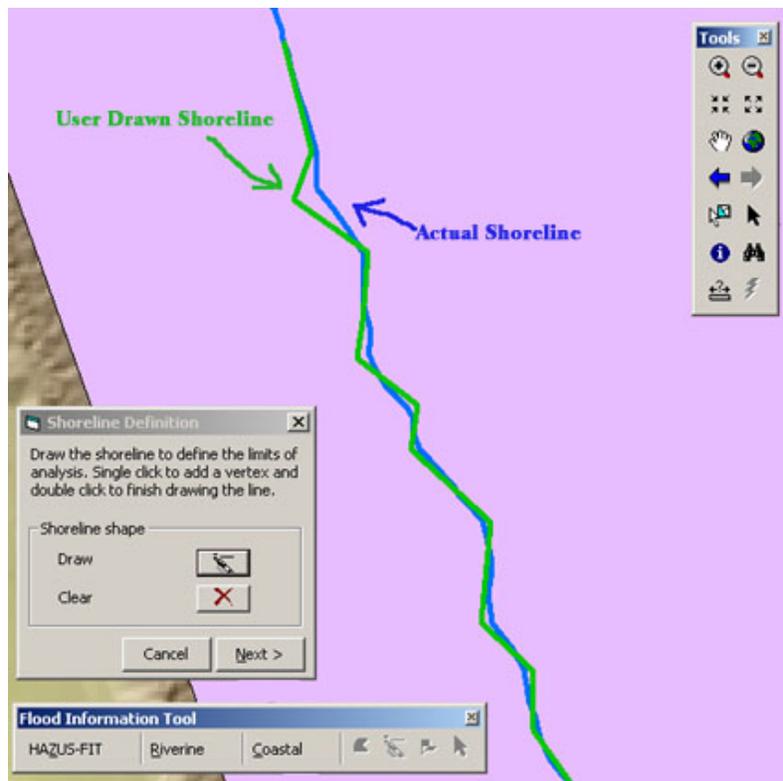


**Figure 2-42: Shoreline Occurs Too Far Landward**

An example of a correctly drawn shoreline is shown in Figure 2-43. See Figure 2-44 for an example of a shoreline incorrectly drawn because the user attempted to include every small-scale change in the shoreline. The shoreline shown in Figure 2-44 presents problems because the analysis transects constructed perpendicular to it will vary greatly in orientation, and will likely not be perpendicular to the general shoreline and any dune features. Frontal dune analysis and eroded ground interpolations will be compromised by the resulting transect orientations. It is for this reason why the **FIT** requires users to draw the shoreline instead of accepting input of the locally-available shoreline/water line map layer.



**Figure 2-43: Shoreline Correctly Drawn**



**Figure 2-44: Shoreline Incorrectly Drawn**

⇒ Click **Draw**.

*The cursor changes from an arrow to a crosshair when held over the active map, indicating that the Draw Polyline tool is active.*

⇒ To draw the desired shoreline polyline, single click to add a vertex and double click to finish drawing.

⇒ To delete the shoreline polyline, click **Clear**.

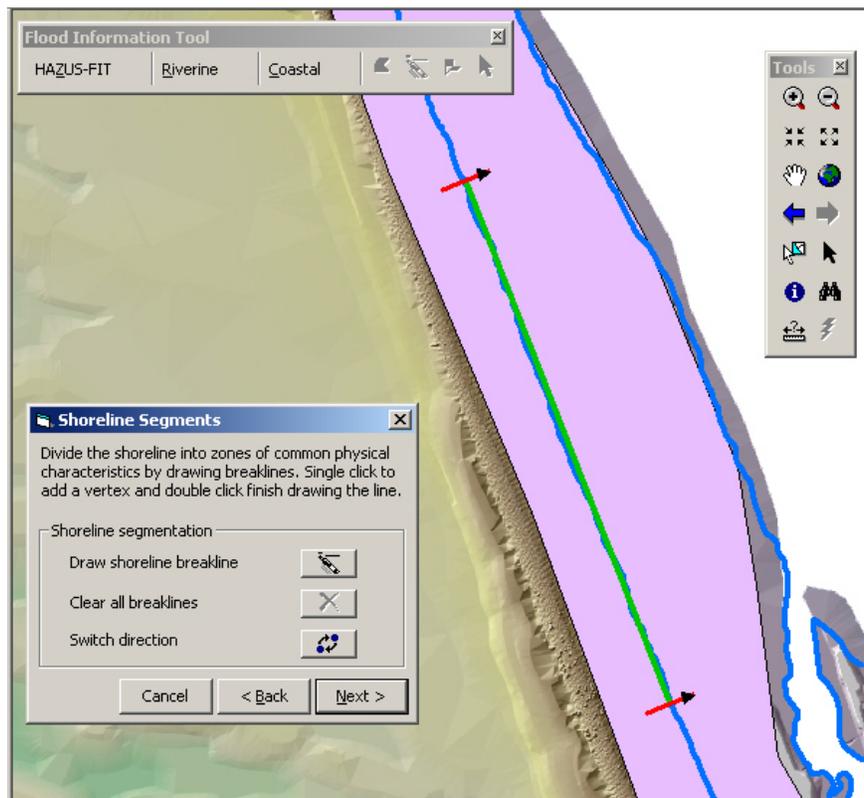
*The Next button is activated once the shoreline has been defined.*

⇒ Click **Next >**.

*The **FIT** uses this map layer as the starting point for transects.*

*The Shoreline Segments dialog is displayed as shown in Figure 2-45.*

The *Shoreline Segments dialog* allows the user to split the shoreline into segments of shared physical characteristics, wave conditions or stillwater elevations. The user can then enter descriptive information regarding each segment.



**Figure 2-45: Shoreline Segments Dialog**

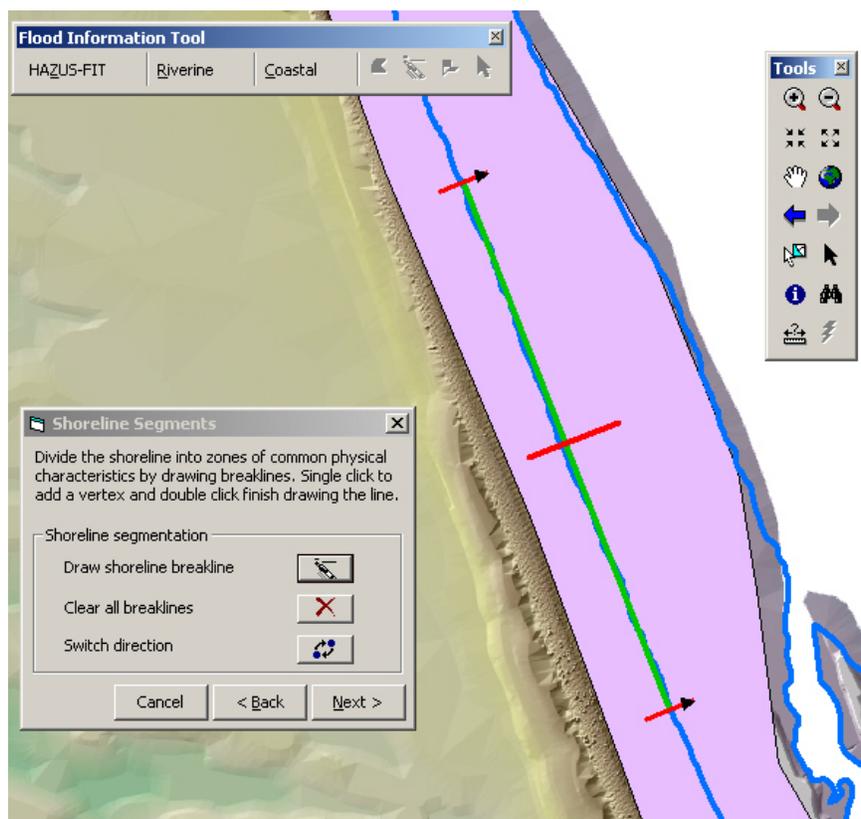
- ⇒ Click **Draw shoreline breakline** to visually create polyline segments on the map to represent the various shore segments.
- ⇒ Draw the polyline segments that demark changes in the shoreline. Single click to add a vertex and double click to finish drawing.



Shoreline segments should be divided according to one or more of the following criteria: shared physical characteristics, same stillwater elevations or wave conditions. FIT accepted shoreline types are rocky bluff; sand/sediment bluff, little beach; sandy beach, small dunes; sandy beach, large dunes; open wetlands; erosion protection structure. See Figure 2-49.

In some cases, Stillwater elevations and shoreline types may be uniform along a study shoreline, but segments should still be created. One such instance will occur along bluff of steeply sloped shorelines where wave runup elevations control base flood conditions, and where BFEs shown on the FIRM step up or down several feet in the longshore direction (despite similar Stillwater elevations and shoreline types). The user should draw breaklines corresponding to divisions between different BFE zones along the shoreline.

The segments created should not be shorter than 100 ft. The **FIT** will display an error message in those cases.



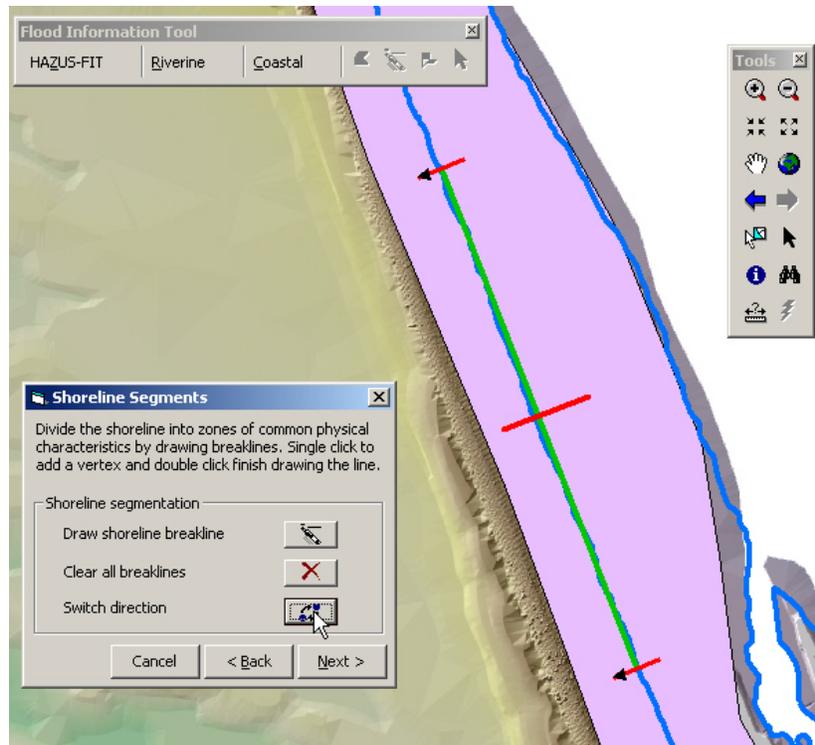
**Figure 2-46: Shoreline Segments Dialog with Multiple Shoreline Segments Displayed**

- ⇒ Click on **Clear all breaklines** to delete all of the user defined shoreline segments.

*The endlines of the shoreline are displayed with arrows indicating the direction from flood source to land.*

- ⇒ As needed, click on **Switch direction** to reverse the direction of the arrowheads.

*The map redisplay the shoreline with the arrowheads on the start and end shoreline points in the reverse direction as shown in Figure 2-47.*



**Figure 2-47: Shoreline Segments Dialog with Wave Direction Reversed**

- ⇒ If you need to return to the *Shoreline Definition dialog*, click **< Back**. All changes will be preserved unless any of the previous dialogs are changed.
- ⇒ Click **Next >**.

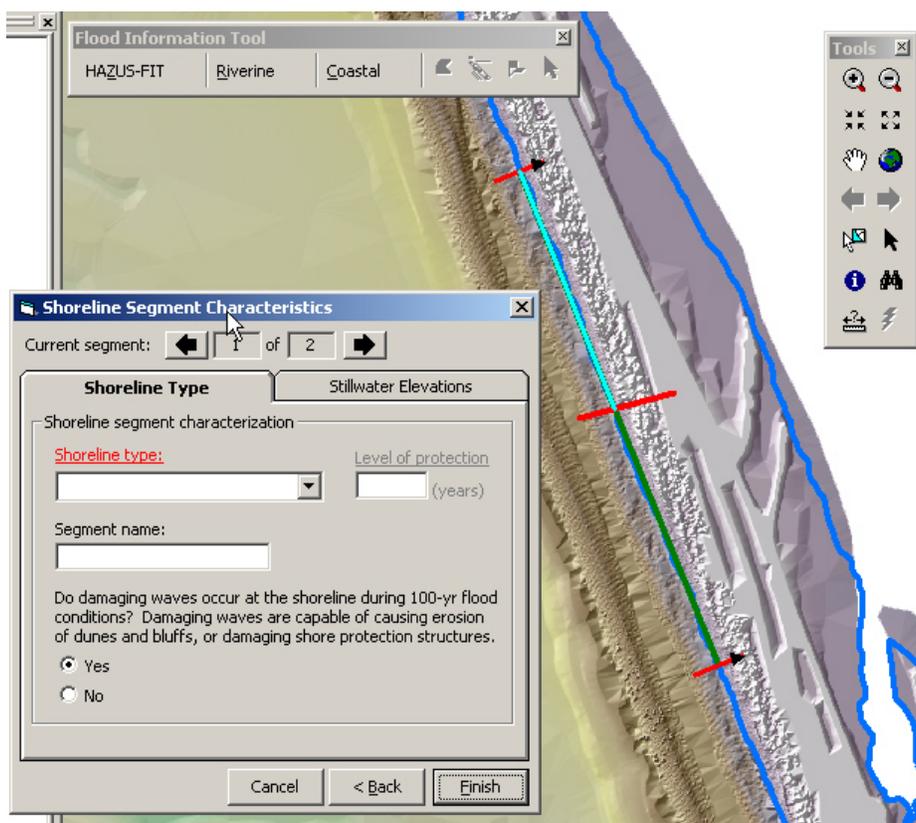
*The Shoreline Segments dialog closes and the Shoreline Segment Characteristics dialog is displayed. See Figure 2-48.*

The *Shoreline Segment Characteristics dialog* requires the user to define the type of shoreline along each segment and identify flood parameters. In the upper portion of the *Shoreline Segment Characteristics dialog* is a box labeled **Current segment**: which shows the user the current shoreline segment upon which they are working.

The *Shoreline Segment Characteristics dialog* consists of two tabs:

- **Shoreline Type:** Allows the user to select a shoreline segment, identify the shoreline type and indicate if damaging waves (i.e., those capable of eroding dunes and bluffs, or damaging shore protection structures) occur at the shoreline during 100-year flood conditions.
- **Stillwater Elevations:** Allows the user to input stillwater elevations for a select range of return periods.

### Shoreline Type Tab

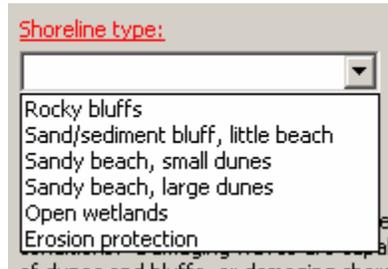


**Figure 2-48: Shoreline Segment Characteristics Dialog – Type Tab**

- ⇒ Select the desired shoreline segment by clicking on either the left or the right **Current Segment** action buttons. The current shoreline segment is displayed in the text box in the middle.

*The selected shoreline segment is highlighted on the map.*

- ⇒ Select the appropriate shoreline type from the dropdown list box labeled **Shoreline type** (Required). See Figure 2-49.



**Figure 2-49: Shoreline Type**

*If the Erosion protection option is selected, the Level of Protection (years) text box is enabled, and the user must add a protection level between 10 and 500 years.*



Level of Protection refers to upland protection against both flooding and flood-induced erosion. The crest elevation of an erosion protection structure should be several feet higher than the stillwater level coinciding with the level of protection entered in the dialog. Otherwise, wave runup and overtopping will affect the area landward of the structure. The erosion protection structure must be able to withstand wave and flood effects, including scour at the base and sides, during the return period entered in the Level of Protection dialog.

- ⇒ Enter a name for the segment in the **Segment Name** text box. (Optional)
- ⇒ Indicate if damaging waves occur at the shoreline during 100-yr flood conditions by clicking on the **Yes** or **No** radio button.

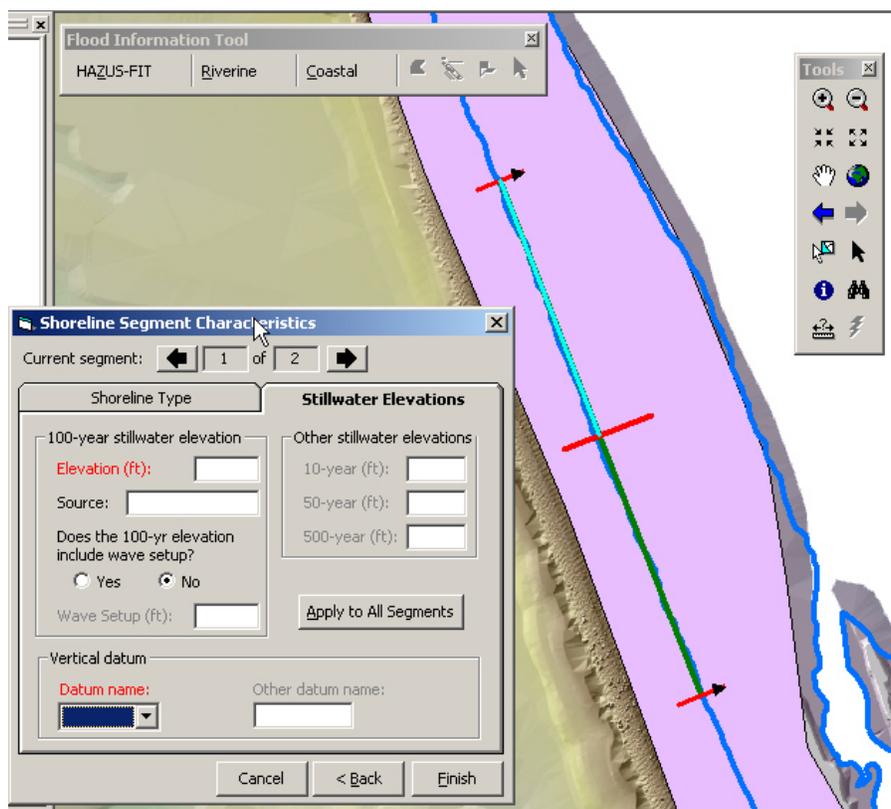
*The default response is yes. If the user selects “No” the FIT assumes stillwater flooding occurs along the shoreline segment, and that no flood-induced erosion will occur.*

- ⇒ Repeat the above steps for each segment. (Required)

## Stillwater Elevations Tab

- ⇒ Click on the *Stillwater Elevations Tab* to input Stillwater elevations for a 100 year return period.

The *Stillwater Elevations Tab* dialog is displayed on the *Shoreline Segment Characteristics* dialog as shown in Figure 2-50.



**Figure 2-50: Shoreline Segment Characteristics Dialog - Stillwater Elevations Tab**

- ⇒ Enter the 100-year stillwater elevation in effect in the **Elevation** text box. Numeric values with decimals are accepted

Sample data: Input **8.9 ft**.



The user can obtain the 100-year stillwater elevation (and the 10-year, 50-year and 500-year stillwater elevations) from the Flood Insurance Study (FIS) report, which accompanies the Flood Insurance Rate Maps for the community. The elevations are contained in the “Summary of Stillwater Elevations” table in the FIS.

The user should make sure that 100-yr BFEs corresponding to a particular segment are greater than the 100-yr SWEL of that segment, but less than or equal to the 100-yr SWEL + 25 ft.

- ⇒ Enter the name of the source in the **Source** text box. (Optional)

- ⇒ Indicate if the 100-yr elevation includes wave setup, by clicking on the **Yes** or **No** radio button.

Sample data: Select **Yes**.



The 100-year stillwater elevation from FIS should be input into the **FIT**. If the 100-year stillwater elevation includes wave setup, this value should still be input, the option button **Yes** selected, and the wave setup (feet) put in the appropriate box. The **FIT** will remove the wave setup from the 100-year stillwater elevation prior to calculating the 10-year, 50-year, and 500-year elevations. If wave setup is included in the 100-yr. stillwater elevation, but the **Yes** option button is not selected and the setup value is not input by the user, the effect will be to overestimate the 10-yr, 50-yr, 500-yr and interpolated flood elevations surfaces.



The user can determine whether wave setup is included in the 100-year stillwater elevation by reading the FIS carefully. If the user is uncertain or if the FIS is not clear on this point, the user can plot the stillwater elevations (linear scale) versus return period (log scale). The points should fall on approximately a straight line on the plot. If the 100-year point lies above a line drawn through the other points, the distance from the line to the 100-year point can be approximated as the wave setup.

*When the Yes radio button is selected, the Wave Setup (ft) text box is enabled as a required field.*

- ⇒ Enter a value for the wave setup between 0 and 3 ft. in the **Wave Setup (ft)** text box. Numeric values with decimals are accepted.

Sample data: Input **2.5 ft.**

*Once the 100-year stillwater elevation and wave setup data have been entered, values are displayed in the text boxes in the Other SWEL group box.*

- ⇒ Edit the stillwater elevation information for each return period in the *Other stillwater elevations* group text boxes as needed. Numeric values with decimals are accepted.



The user can replace the values calculated by the **FIT** using data from the “Summary of Stillwater Elevations” table in the FIS. If the table in the FIS does not contain an elevation for a particular return period, use the value calculated by the **FIT**.

- ⇒ Select the vertical datum from the **Vertical Datum** list box. (Required)

Sample data: Select **NGVD29**.

*If Other is selected in the Vertical Datum list box, the Other Vertical Datum text box is enabled.*

- ⇒ Enter the vertical datum name in the **Other Vertical Datum** text box as required. This datum should match the one selected in the *Project Setup and Validation* dialog.

- ⇒ If the stillwater elevation information for all segments is the same or very similar, click **Apply to All Segments** and edit the stillwater elevation for each segment as needed. Otherwise repeat the above steps for each segment.

*When all of the required information for each segment is defined, the Finish button is enabled.*

- ⇒ Click **Finish**.

*The Shoreline Segment Characteristics dialog closes and the Main Window appears. The Edit Transects, Frontal Dune Analysis, and Calculate 100-Yr Depth Grid options on the Coastal menu are enabled.*

*Upon selection of Finish, an algorithm is launched to create a series of shore-normal transects. The Transects are numbered in ascending fashion starting with 1 at the start of the shoreline through x at the end point of the shoreline. The shore-normal transects are developed as polylines, to the shoreline defined by the user, and will not extend beyond the user's Analysis Boundary. The polylines will appear on the active map layer for the users visualization and editing. The transects are constructed in the same direction as the shoreline endlines previously displayed with the Shoreline Segments dialog, and should point toward land. If the direction of the transects is incorrect, it is important to re-run the shoreline wizard to correct the error. During the process of creating the shore-normal transects, a series of checks are performed to make sure that the transects are not completely submerged and each has at least 500 ft. of length on the land (above reference elevation). If one of these checks fails the user will be shown the appropriate error message (see Figure 2-35 through Figure 2-42). The user can find out at which transect the process was stopped by opening the attribute table of transects feature class and looking at the column named "Complete". The transects that passed the checks will have the word "YES" on that column.*



It is recommended that the user save the file before proceeding to the next menu option.

- ⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

### 2.5.3 Edit Transects (Optional)

Once the *Shoreline Wizard* has been completed, the **Edit Transects** option is available on the **Coastal** menu. Selection of **Edit Transects** allows the user to add new transects, or delete any added transects. The location of **FIT** generated transects cannot be altered.

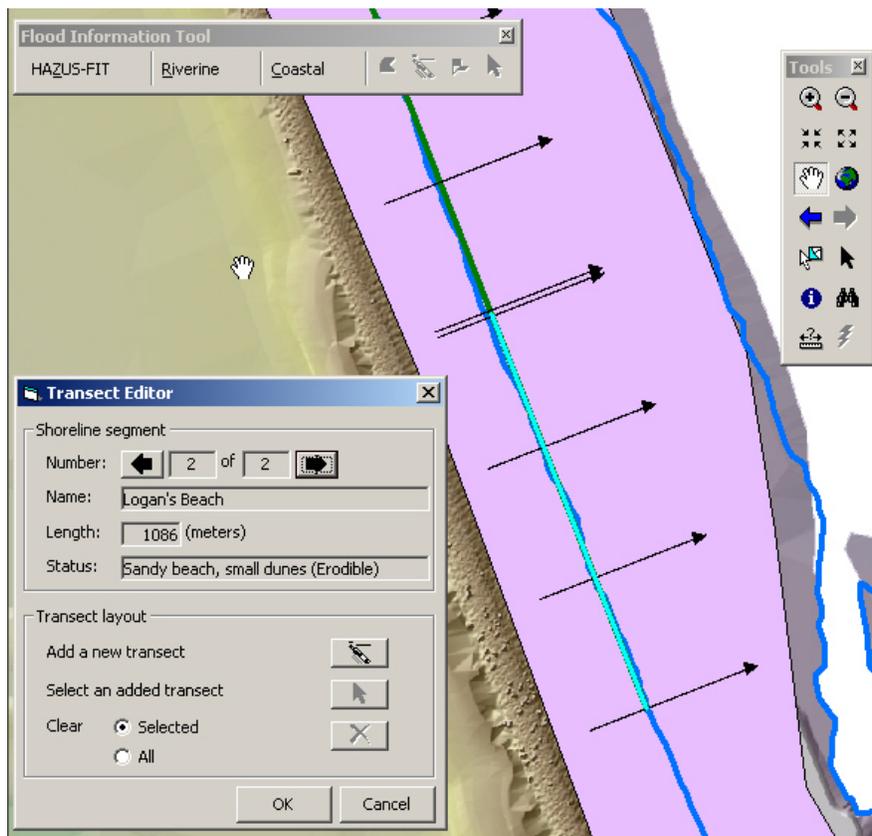


Transects are used by the Coastal **FIT** to model flood-induced erosion of the frontal dune (the eroded ground surface affects the flood surface and flood depths). Transects are drawn by the **FIT**, perpendicular to and extending landward from the shoreline.

The user must have completed the **Shoreline Wizard** to activate the **Edit Transects** option on the **Coastal** menu, but use of the editing functionality is optional. Users may wish to add transects to achieve a tighter transect spacing or to place transects at selected locations.

⇒ Select **Edit Transects** from the **Coastal** menu located on the *Flood Information Tool* toolbar.

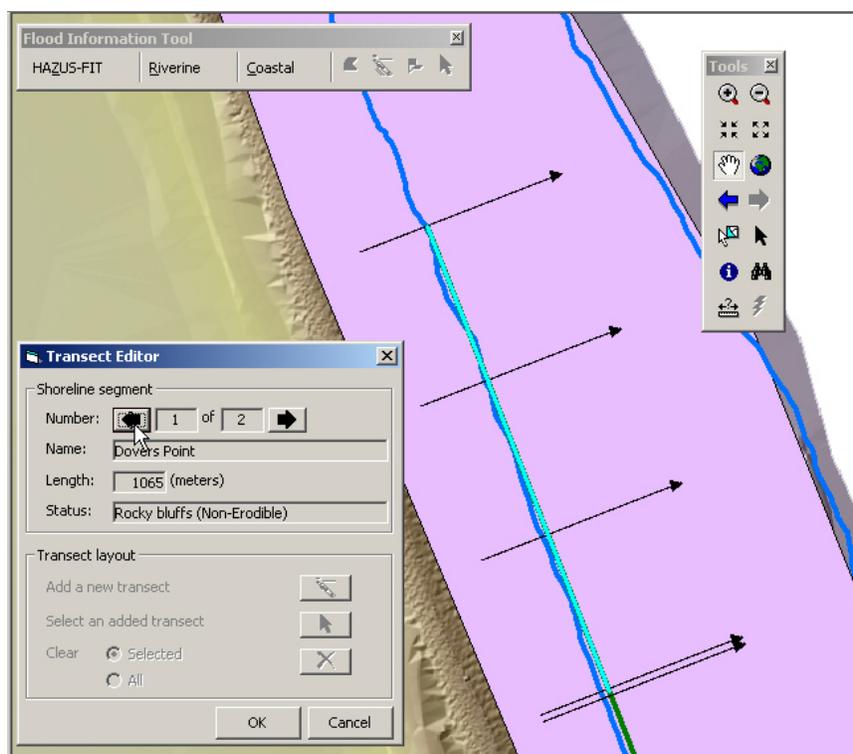
*The Transect Editor dialog is displayed as shown in Figure 2-51. The map zooms into the selected segment and displays the selected segment in a highlighted mode with the existing transects.*



**Figure 2-51: Transect Editor Dialog**



For non-erodable shore segments (rocky bluffs, high levels of erosion protection, or open wetlands), the *Transect Editor dialog* displays the shore segment information but the Transect Layout options are disabled as shown in Figure 2-52.



**Figure 2-52: Transect Editor for Non-Erodible Shoreline Segment**

- ⇒ Select the desired shoreline segment by clicking on the previous or next button labeled **Number**.

*The information for the selected shore segment is displayed.*

- ⇒ To add a new transect, click on the **Add a new transect** button to activate the **Draw line** tool.

*The FIT transect draw tool is activated.*

- ⇒ Draw a line that intersects the current segment at the point where the new transect will be added. Clicking on the map will add a vertex and double clicking will finish drawing.

*The added transect is perpendicular to the shoreline and is shown in red. It may extend beyond the Analysis Boundary, but will be clipped once OK is clicked.*

- ⇒ To delete a transect, select the transects to be deleted by using the **Select an added transect** tool. When the **Select** tool is activated, dragging a box around the transect or clicking on it will select it. Once you have selected a transect, click on the **Selected** radio button and click **Clear** to delete it.

Alternately, clicking on the **All** radio button and clicking the **Clear** button will delete all of the user defined transects on the current segment.



The user is not allowed to delete transects developed automatically by the **FIT**. This enables the **FIT** to maintain the maximum transect spacing. Users are allowed to add transects to enhance the **FIT**'s accuracy. Users are also able to delete transects they have added before they click **OK** and make them permanent.

- ⇒ Repeat as needed for the remainder of the shoreline segments.
- ⇒ Click **Cancel** to discard edits.
- ⇒ Click **OK** to accept the edits and make them permanent.



After added transects are made permanent, the only way to go back to the original transect layout is to restart the Shoreline Wizard.

*The Transect Editor dialog is closed and transects are renumbered based on the newly added transects. The **FIT** will clip them if necessary to make sure that they do not extend beyond the user's Analysis Boundary.*



It is recommended that the user save the ArcMap document before proceeding to the next menu option.

- ⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

## 2.5.4 Frontal Dune Analysis (Optional)

Once the *Shoreline Wizard* has been completed, the **Frontal Dune Analysis** menu item is enabled on the **Coastal** menu.



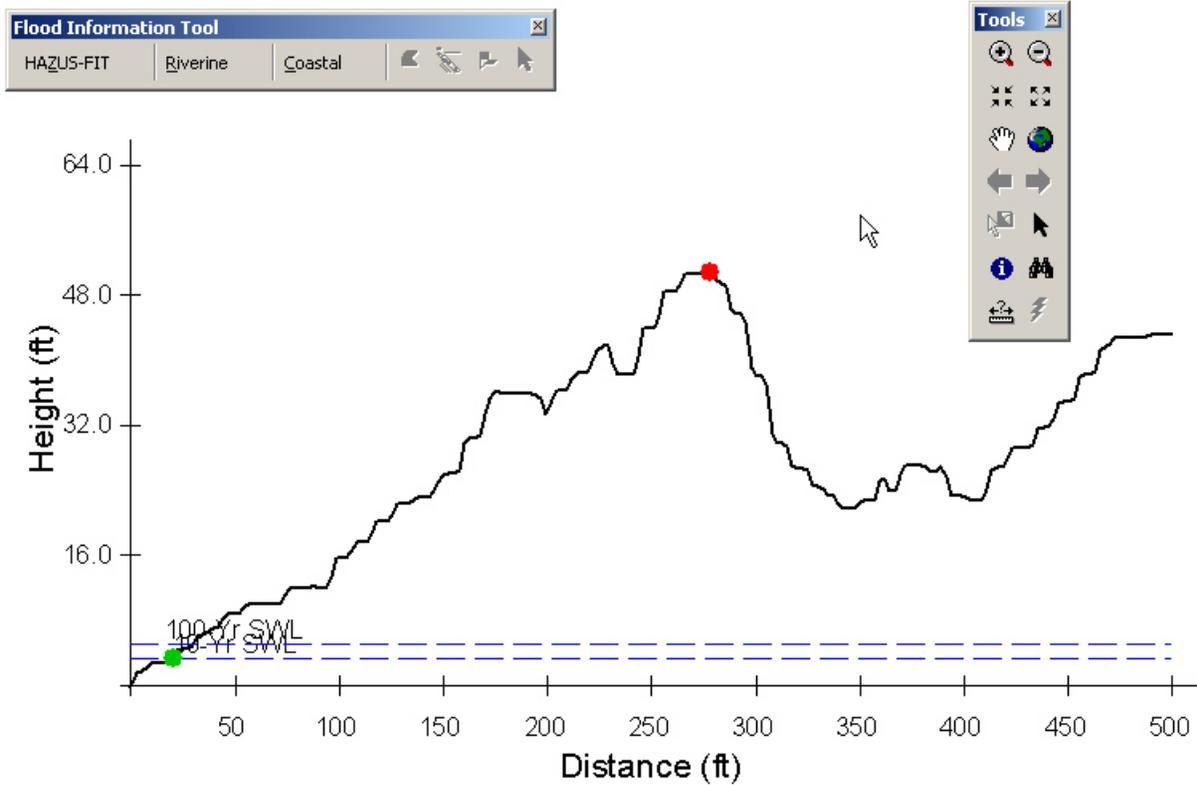
The FIT will perform a frontal dune analysis (flood-induced erosion analysis) for transects lying in shoreline segments classified as erodible and with damaging waves present.

The **Frontal Dune Analysis** option allows the user to change the location of the frontal dune toe and peak for each transect, but does not allow the user to forsake the analysis itself.

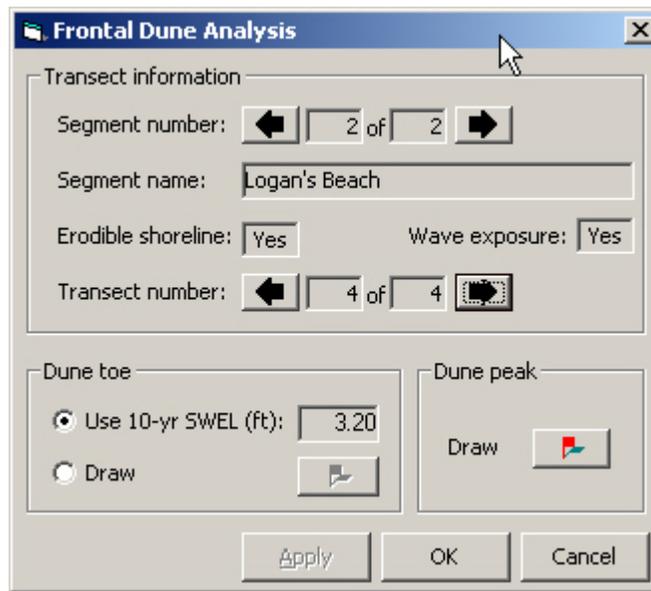
- ⇒ Select **Frontal Dune Analysis** from the **Coastal** menu to access the *Flood-Induced Erosion dialog*.

*The Frontal Dune Analysis dialog is displayed, shown in Figure 2-54, and a new data frame within ArcGIS is launched and displayed as shown in Figure 2-53. The data frame has an x- and y-axis with the x-axis representing the distance inland from the actual shoreline. In the cross-sectional profile, the shoreline represents the (0,0) point. Those transects identified on the Shoreline Segment Characteristics dialog (Figure 2-48) as lying in a shoreline segment exposed to damaging waves and with a shoreline type capable of being eroded, can be edited*

*Flood-induced erosion of the frontal dune is only considered within 500 ft of the shoreline.*



**Figure 2-53: Data Frame for Erosion Analysis**



**Figure 2-54: Flood-Induced Erosion**

⇒ Select the transect to be defined by either clicking on the arrow to the right or the left of the **Transect number** text box displaying the current transect.

The FIT will assign the dune toe to the intersection of the transect profile and the 10-year SWEL. The user has the option to use this toe, or select another using the Select button.

- ⇒ In the *Dune toe group* box, elect to use the 10-yr stillwater elevation by leaving the **Use 10-yr SWEL** radio button selected or select **Draw** to draw the toe on the dune profile.



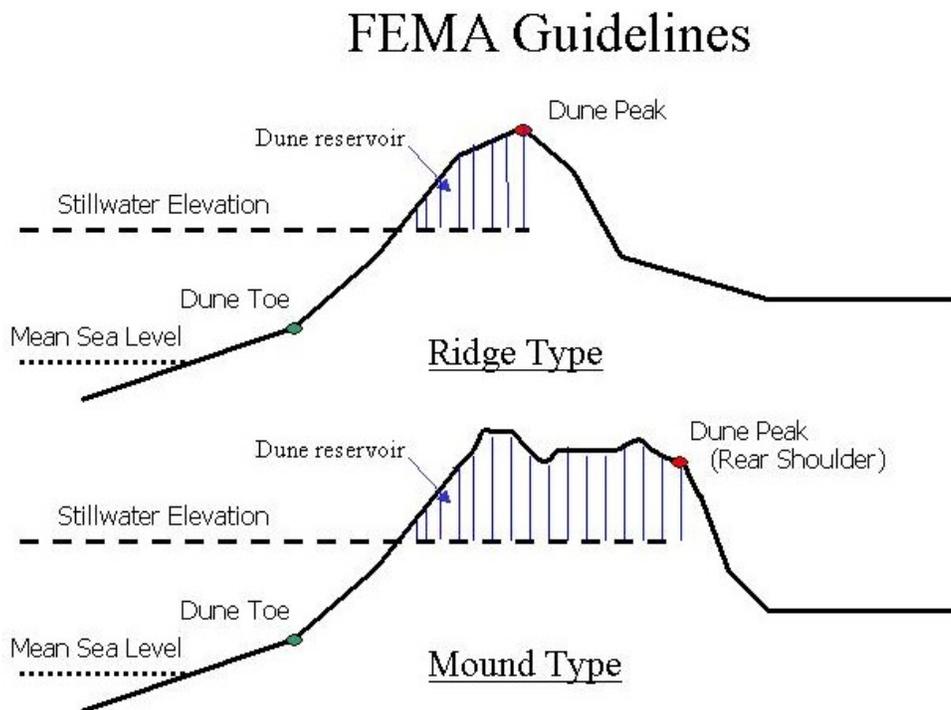
The toe should lie at the transition between the horizontal beach and the steep slope of the dune/bluff -- at the base of the slope. If the default 10-yr SWEL elevation intersects the transect on the beach or lies too high on the slope, the flood-induced erosion assessment results may be incorrect and the user should select the correct toe location.

The FIT will select and display a peak for the user. The user has the option to use this peak or draw another using the Draw button.

- ⇒ In the *Dune Peak group* box, select **Draw**.
- ⇒ Using the Draw Tool that is enabled, draw the dune peak on the dune profile by clicking on the appropriate place on the displayed map.

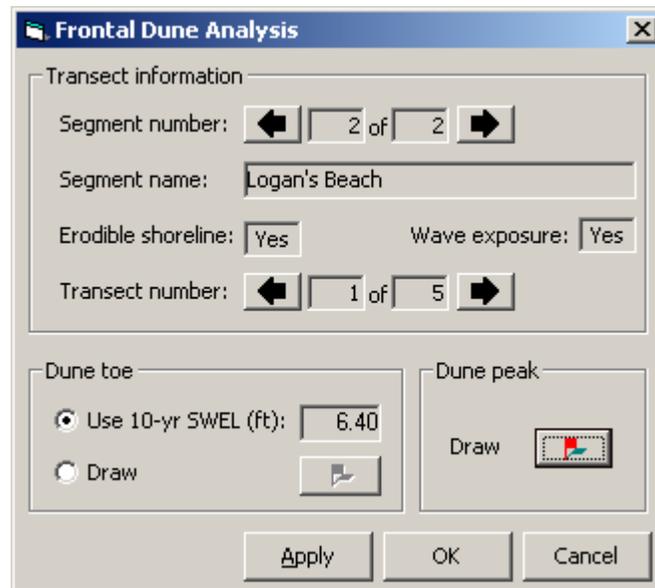


The dune peak should lie at or near the top of the dune, close to the upper limit of the steep slope on the dune's landward side (see Figure 2-55).



**Figure 2-55: Guidance for User Selection of Dune Peak**

The dune peak is repositioned and the Apply button is enabled on the Frontal Dune Analysis dialog as shown in Figure 2-56.



**Figure 2-56: Frontal Dune Analysis with Apply Enabled**

⇒ Click **Apply**.



The peak should lie at the maximum elevation of a single dune profile, or at the top of the slope on the landward side of a profile with multiple peaks. If the profile contains a bluff (nearly horizontal ground surface lying atop a steep slope), select the landward-most point on the bluff).

⇒ Repeat for each transect. (Optional)

⇒ Click **OK**.

*A polygon coverage representing the flood extent is created.*

⇒ Click **OK**.



It is recommended that the user save the ArcMap document before proceeding to the next menu option.

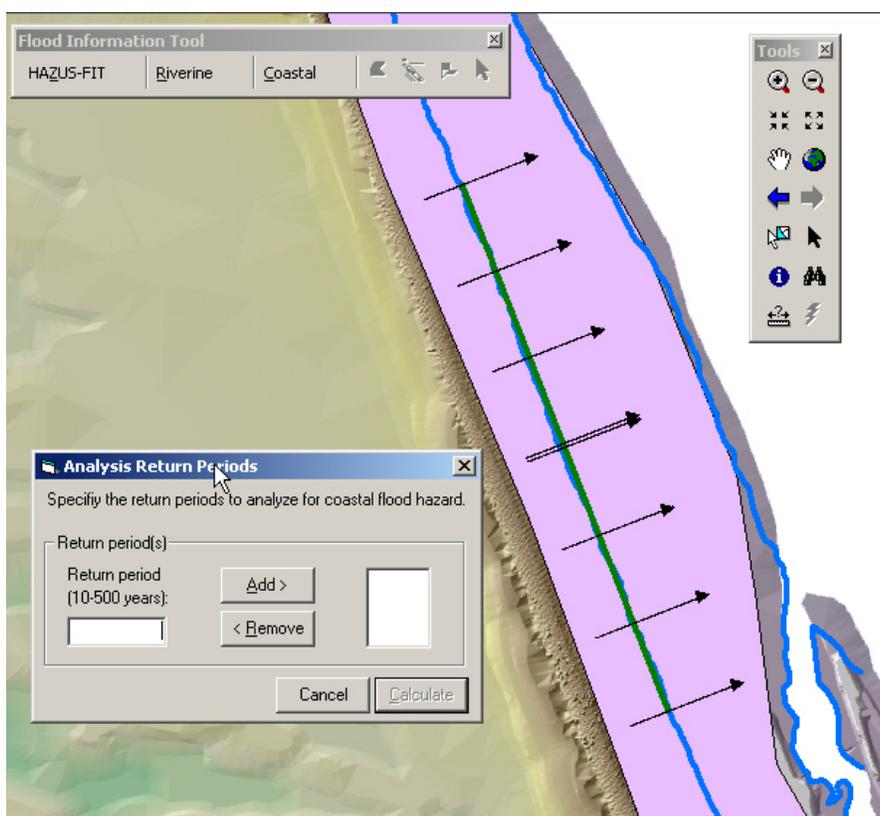
⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

## 2.5.5 Calculate Hazard Grids

Once the *Shoreline Wizard* has been completed, the **Calculate Hazard Grids** option appears on the **Coastal** menu. The **Calculate Hazard Grids** option on the **Coastal** menu, activates the Analysis Return Periods dialog which allows the user to specify additional return periods to be interpolated and new depth grid created for each. The user can select flood return periods between 10-year and 500-year.

⇒ Select **Calculate Hazard Grids** on the **Coastal** menu.

*The Analysis Return Periods dialog is displayed as shown in Figure 2-57.*



**Figure 2-57: Analysis Return Periods Dialog**

⇒ Enter a return period in the **Return period (10-500 years)** text box.

Sample data: Input **100**.

⇒ Click **Add>**.

*The value entered in the Return Period (yr) text box is transferred to the list box on the right.*

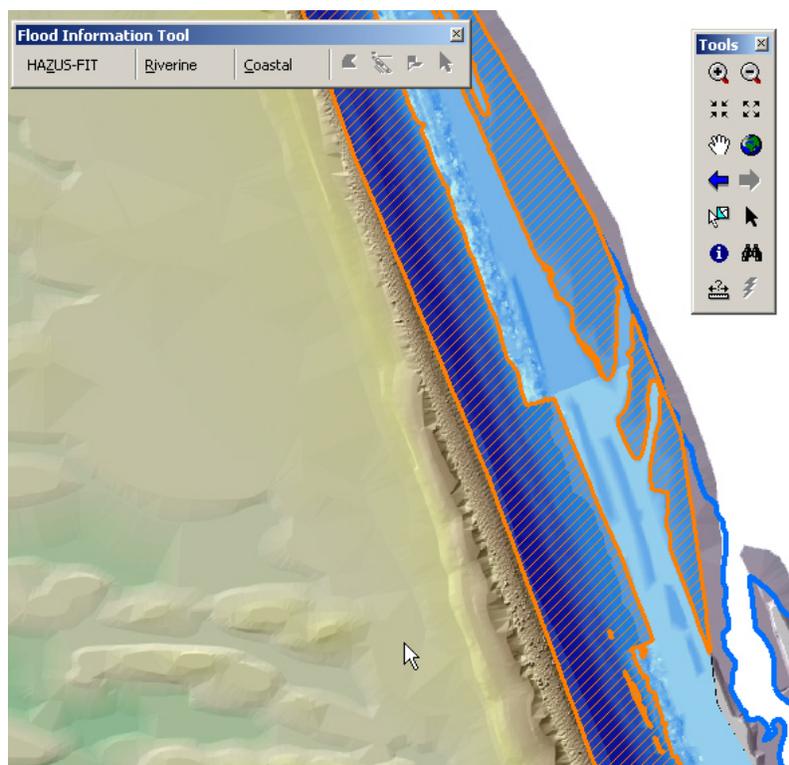
⇒ Repeat for additional return periods.

- ⇒ To remove a return period from the list box on the right, select the return period in the text box on the right and click **Remove**.

*The selected return period is removed from the list box on the right.*

- ⇒ Click **Calculate** to start the analysis.

*The Analysis Return Periods dialog is closed. A depth grid for each of the defined return periods is produced. An eroded profile is created at each transect where flood-induced erosion occurs, and the flood depth along each transect is computed. Once the calculations have been completed for each transect, the model will start interpolating eroded ground elevations and flood depths between transects. Once the analysis is complete, a figure similar to Figure 2-58 is displayed.*



**Figure 2-58: Analysis of Return Periods Complete**



It is recommended that the user save the ArcMap document before proceeding to the next menu option.

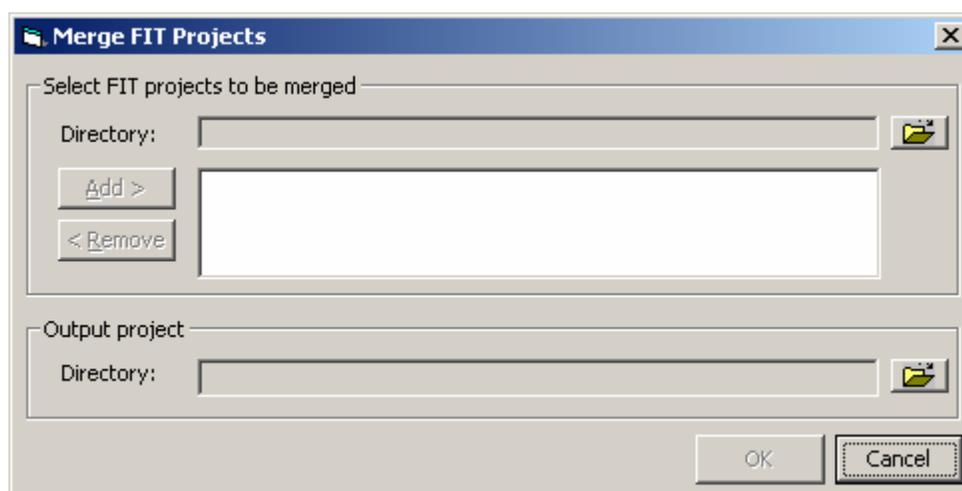
- ⇒ Click the **Save** toolbar icon or select **Save** from the ArcMap **File** menu.

## 2.6 Merge FIT Projects

Users are able to merge the depth and elevation grids (hazard, and flood-induced erosion) as well as output shapefiles of multiple projects into a single project so that they can be sent to the *HAZUS Flood Model* together instead of separately. This capability is provided in the **Merge FIT Projects** option on the **HAZUS\_FIT** menu located on the *Flood Information Tool* toolbar.

⇒ Select **Merge FIT Projects** from the **HAZUS\_FIT** menu.

*The Merge FIT Projects dialog is displayed as shown in Figure 2-59. This dialog allows the user to select the projects to be merged.*



**Figure 2-59: Merge FIT Projects Dialog**



Merging Coastal and Riverine projects is not allowed. The grids and output shapefiles will be sent separately to the *HAZUS Flood Model* where the individual damage functions will determine the controlling flood source for each occupancy classification. In other words, losses will be estimated for both grids and the flood model will select the highest damage value for each occupancy and census block.

### Merging Grids:

To select the **FIT**'s projects to be merged:

- ⇒ Click on the **Open File** icon of the **Directory** in the *Select FIT projects to be merged* group box; navigate to the location of the project folder to be merged, single click the project folder and click **Select**. Do not double click.
- ⇒ Click **Add**.

*The name of the selected **FIT** project folder is displayed in the list box.*

- ⇒ Repeat for each **FIT** project to be merged.

⇒ To remove a **FIT** project from the list box, select the project and click **Remove**.

*The selected **FIT** project is removed from the list of projects to be merged.*

To define the **FIT** project:

⇒ Click on the **Open File** icon of the **Directory** in the *Output project* group box; navigate to the location of the project folder for the output project, select the project folder and click **Select**. (Required)

⇒ Click **OK**.

*All of the **FIT** projects that were listed in the list box are merged into one and saved under the output project directory.*



At least two **FIT** projects have to be added to the list box and the output project defined for the **OK** button to become enabled. There is no limit on the number of projects to be merged at one time but it should be noted that increasing the number will increase the processing time.

## Appendix A – Input Data and Conversion Methods

### A.1 ESRI GIS Data Formats

#### A.1.1 ArcInfo Grid

This is the input data format required by the **FIT** for both riverine and coastal analysis. No conversion is required.

#### A.1.2 Polyline Flood Elevations

This is the input data format required by the FIT for riverine flood elevations. No conversion is required if in the polyline feature class format. Examples of flood elevation polylines are DFIRM BFE lines, digitized BFE lines, and digitized hydraulic model cross-sections. Each polyline should be attributed with one or more flood elevation(s) and the polylines should not intersect one another.

#### A.1.3 Polygon Floodplain Boundaries

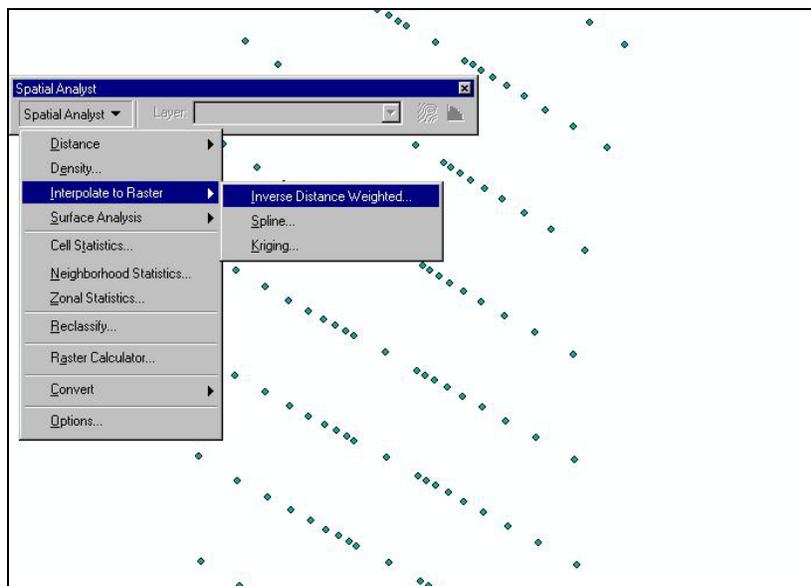
This is the input data format required by the FIT for both riverine and coastal analysis. No conversion is required if in the polygon feature class format. Examples of floodplain boundary polygons include the FEMA Q3 and digitized floodplain polygons.

#### A.1.4 Polygon Flood Elevations

This is the input data format required by the FIT for coastal flood elevations and flood hazard zones. No conversion is required if in the polygon feature class format. Examples of coastal flood elevation polygons include the FEMA DFIRM and digitized flood elevation polygon. Each polygon should be attributed with a flood elevation, FEMA flood hazard zone, and sheet flow (AO/VO zone) depth (if applicable).

### A.1.5 Mass Points

The conversion of Mass Points requires the use of Spatial Analyst's interpolation methods (e.g. Spline, Inverse Distance Weighted) to interpolate points to raster. See Spatial Analyst documentation for further information on different methods of point interpolation.

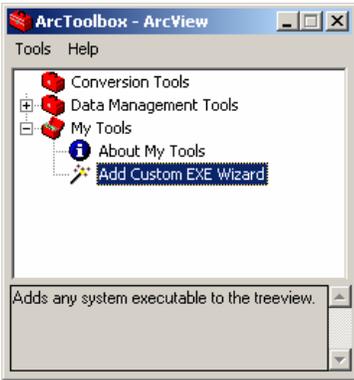


LIDAR data must be preprocessed to represent bare earth conditions before performing the conversion to the FIT format.

### A.1.6 Polyline Contours

The ArcGIS Spatial Analyst extension provides vector-to-raster conversion functionality through the menu item **Convert Features to Raster**. However, if used on polyline contour data, the resulting raster contains grid cells at the line locations, but not elsewhere. As such, this method is inadequate for developing a terrain elevation surface across the entire floodplain. Such a surface must be developed through interpolation. However, the ArcGIS raster interpolation routines accept only points as input. As a remedy, the *FIT* includes a standalone utility to convert line contours in a shapefile format, to mass points. The points can then be interpolated to a raster surface as described in Section A.1.2.

To add the Contour Converter to the ArcToolbox:

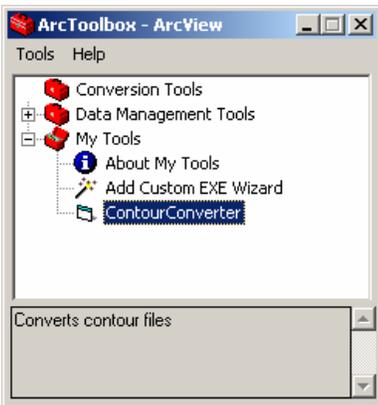


- ⇒ Start *ArcToolbox*.
- ⇒ Expand the **My Tools** folder.
- ⇒ Select **Add Custom EXE Wizard**

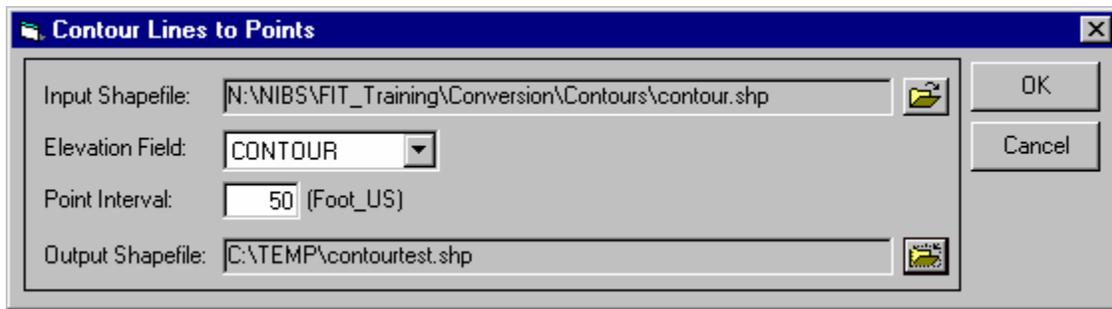


- ⇒ Select the **ContourConverter.exe** from the FIT installation directory.
- ⇒ Complete the remaining Add Custom EXE Wizard steps.

To convert Contour data to Mass Points:



- ⇒ Start *ArcToolbox*.
- ⇒ Expand the **My Tools** folder.
- ⇒ Select **ContourConverter**



- ⇒ Select the Input Shapefile by using the browse button, drag and drop from Windows Explorer, or drag and drop from ArcCatalog.
- ⇒ Select the correct Elevation Field from the contour shapefile attribute table.
- ⇒ Enter the desired Point Interval.



Along each contour line, elevation points will be created using this point spacing. The lower the point interval, the greater the number of resulting points and required processing time. The desired point interval should be determined keeping in mind the trade off between point resolution and processing time. The processing time is dependent upon the following variables:

- Computer hardware configuration
- Point interval
- Length of contour lines
- Number of contour lines

- ⇒ Select the Output directory and define the name of the output file.
- ⇒ Click **OK**.



- ⇒ Click **OK**.
- ⇒ Using the output file, follow the steps for Mass Points. See Section A.1.5.



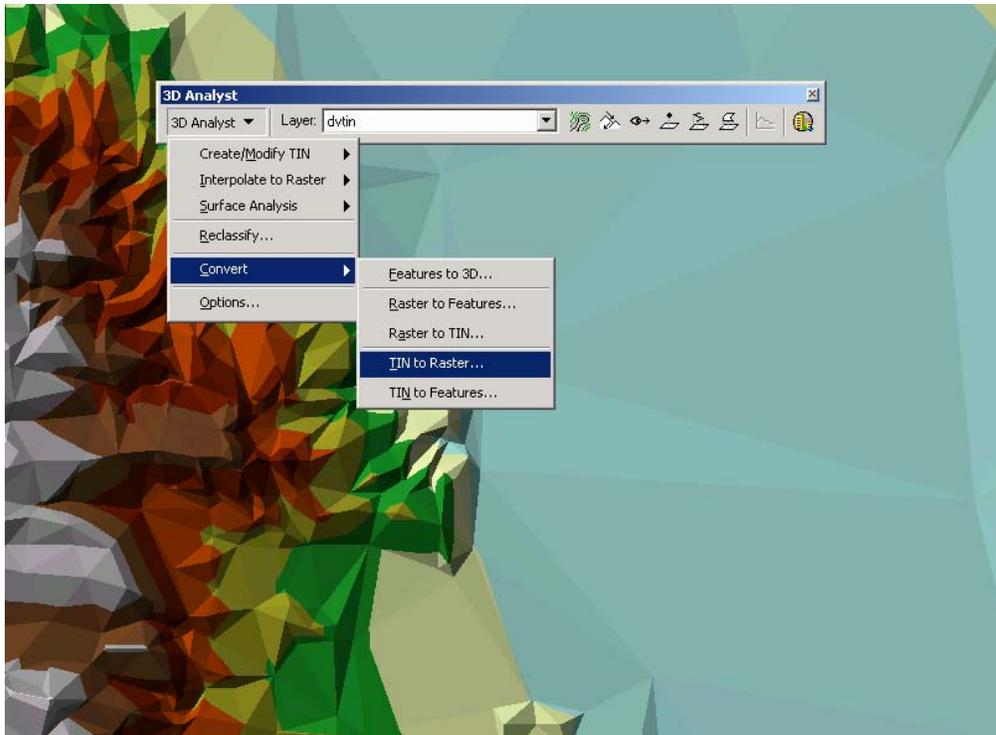
The text strings of the input shapefile and output shapefile boxes may be cut off if the file path is long and contains a space.

### A.1.7 TIN

Conversion of a TIN to raster requires 3D Analyst Extension of ArcView (available with a separate license).

From 3D Analyst menu:

- ⇒ Select **Convert** from the 3D Analyst menu.
- ⇒ **TIN to Raster...** from the Convert menu.
- ⇒ Follow the on-screen instructions.



### **A.1.8 ArcInfo Region**

Need to be converted into the ArcGIS polygon feature class format by user. This will require the use of ArcInfo.

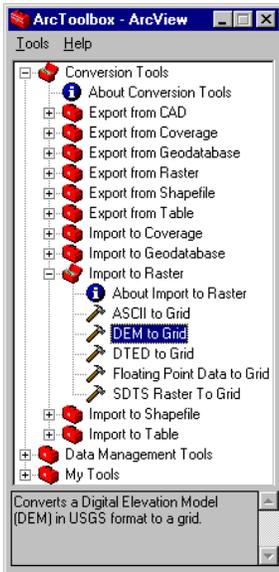
### **A.1.9 Generate File**

This item has been deferred from this release of the FIT. Users with ArcInfo can convert Generate Files into shapefiles.

## A.2 Non-ESRI GIS Data

### A.2.1 USGS DEM

To convert USGS DEM ground elevation data into ArcInfo Grid format:



⇒ Start *ArcToolbox*.

⇒ Expand the **Conversion Tools** folder.

⇒ Expand the **Import to Raster** folder.

⇒ Select **DEM to Grid**

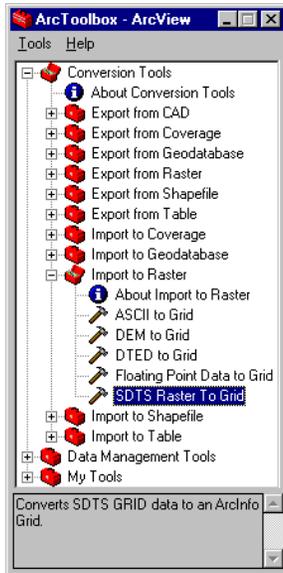


There are reports that this will not work unless:

- a. ArcMap is running and have a project already loaded (not a new one but one that has been saved before and loaded now)
- b. Spatial Analyst is loaded in ArcMap. See Section 2.1.

## A.2.2 USGS SDTS DEM

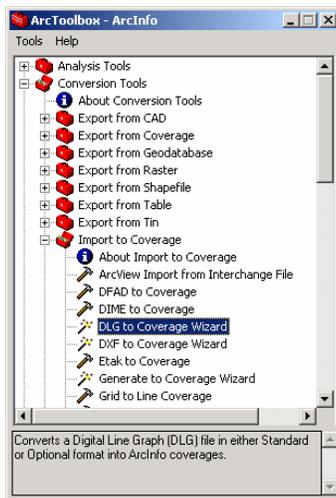
To convert USGS SDTS DEM ground elevation data into ArcInfo Grid format:



- ⇒ Start *ArcToolbox*.
- ⇒ Expand the **Conversion Tools** folder.
- ⇒ Expand the **Import to Raster** folder.
- ⇒ Select **SDTS Raster to Grid**

## A.2.3 USGS DLG

The U.S. Geological Survey digital line graph (DLG) data format is used to store digital vector representations of cartographic information, such as topography, hydrography, and transportation features. Conversion of USGS DLG data to an ArcGIS feature class requires an ArcInfo license:



- ⇒ Start *ArcToolbox*.
- ⇒ Expand the **Conversion Tools** folder.
- ⇒ Expand the **Import to Coverage** folder.
- ⇒ Select **DLG to Coverage Wizard**

### A.2.4 USGS SDTS DLG

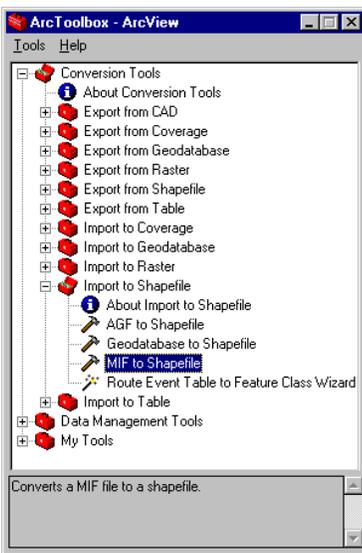
- ⇒ Convert to a data format readable by the ArcView version of ArcGIS vector by using one of the data translators commercially available
- ⇒ Follow the steps for contours. See Section A.1.6.

Examples of commercially available data translators are:

- DLG2SHP at <http://www.gistools.com/> (~\$100)
- FME at [http://www.safe.com/fme\\_desktop.htm](http://www.safe.com/fme_desktop.htm) (15 days free trial, after that ~\$500)
- Also at <http://www.fws.gov/data/gisconv/sdtsovr.html> detailed steps for conversion in ArcView 3.x can be found.

### A.2.5 MapINFO MIF

To convert MapInfo MIF vector data into the ArcGIS shapefile format:



- ⇒ Start *ArcToolbox*.
- ⇒ Expand the **Conversion Tools** folder.
- ⇒ Expand the **Import to Shapefile** folder.
- ⇒ Select **MIF to Shapefile**.

### A.2.6 Microstation DGN

Same as AutoCAD DWG. See Section A.2.7.

## A.2.7 AutoCAD DWG

To convert AutoCAD DWG ground elevation data into ArcGIS feature class format:



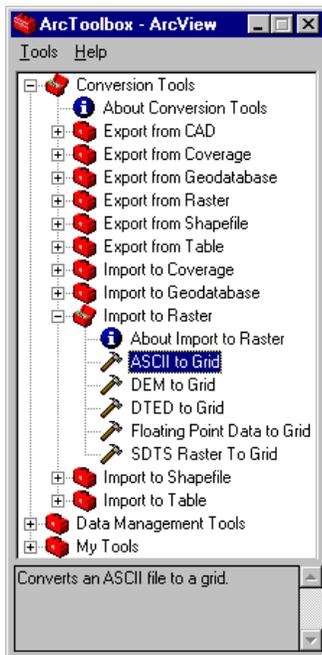
- ⇒ Start *ArcToolbox*.
- ⇒ Expand the **Conversion Tools** folder.
- ⇒ Expand the **Export from CAD** folder.
- ⇒ Select **CAD to Geodatabase**.



The geodatabase should be created before beginning the conversion process. To create a new geodatabase, select **New/Personal Geodatabase** from *ArcCatalog's File* menu.

## A.2.8 ASCII Grid

To convert ASCII Grid ground elevation data into ArcGIS Grid format:



- ⇒ Start *ArcToolbox*.
- ⇒ Expand the **Conversion Tools** folder.
- ⇒ Expand the **Import to Raster** folder.
- ⇒ Select **ASCII to Grid**.

## A.2.9 DXF

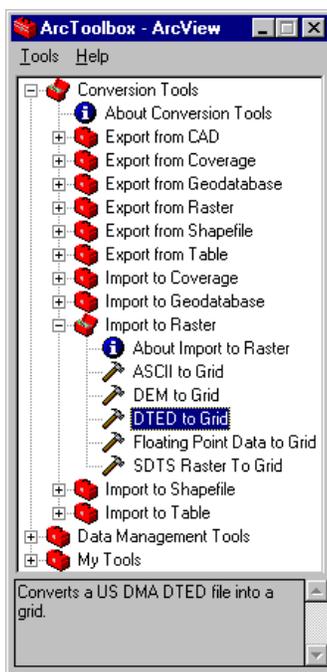
⇒ Use steps described for AutoCAD DWG in Section A.2.7.

## A.2.10 Binary

This item has been deferred from this release of the FIT.

## A.2.11 DTED DEM

To convert DTED DEM ground elevation data into ArcGIS Grid format:



⇒ Start *ArcToolbox*.

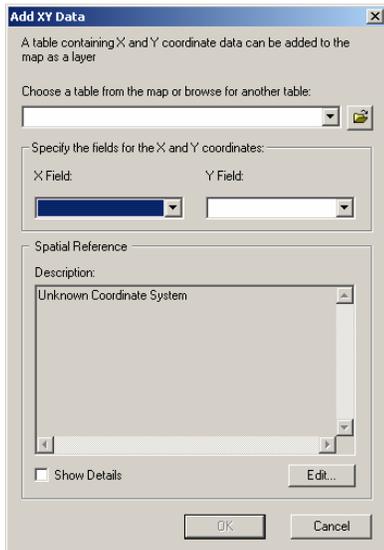
⇒ Expand the **Conversion Tools** folder.

⇒ Expand the **Import to Raster** folder.

⇒ Select **DTED to Grid**.

### A.2.12dBASE Table

Tabular data containing geographic coordinates can be added to ArcMap if the table contains at least two fields: one for the x-coordinate and one for the y-coordinate. To convert a dBASE table into the ArcGIS shapefile format:



- ⇒ Start *ArcMap*.
- ⇒ From the *Tools* menu, select **Add XY Data**.
- ⇒ Browse to the table.
- ⇒ Specify the x and y fields.
- ⇒ Click the **Edit** button to specify the spatial reference.
- ⇒ Click **OK** to close the *Add XY Data dialog*.
- ⇒ Convert the layer to a shapefile by right-clicking the layer in the ArcMap table of contents, and selecting **Data/Export Data**.

### A.2.13 Digital Hydraulic Model Cross-Sections (Georeferenced)

Need to be converted into a GIS by user

### A.2.14 Digitized Streamline and Point Elevations

This item has been deferred from this release of the FIT.

### A.2.15 Digitized Stream Baseline

This item has been deferred from this release of the FIT.

## **A.3 Non-GIS Data**

### **A.3.1 Hardcopy FIRM Polygons**

Need to be digitized by user (e.g.: see <http://www.ncgia.ucsb.edu/cctp/> for help).

### **A.3.2 Hardcopy BFE Lines**

Need to be digitized by user (e.g.: see <http://www.ncgia.ucsb.edu/cctp/> for help)

### **A.3.3 Hardcopy Hydraulic Model Cross-Sections**

Need to be digitized by user (e.g.: see <http://www.ncgia.ucsb.edu/cctp/> for help)

### **A.3.4 Digital Hydraulic Model Cross-Sections (Non-georeferenced)**

This item has been deferred from this release of the FIT.



## Appendix B – FIT File Structure

The location of the output data from the **FIT** is the working directory specified by the user in the *Project Setup and Validation – General Tab dialog*. (See Figure 2-3 for Riverine and Figure 2-4 for Coastal.)



It is important not to alter these files in any way, if the **FIT** is to function properly.

### Riverine

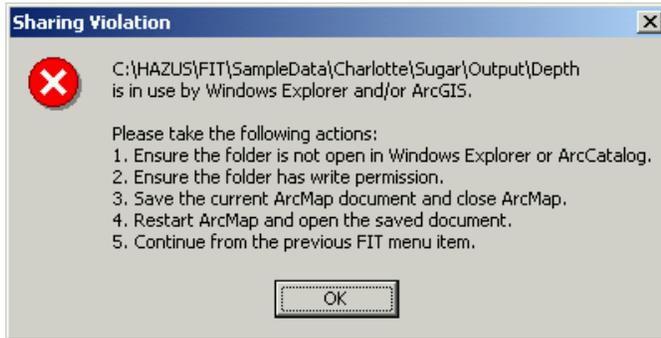
Name	Type	Description
Depth	Folder	Contains raster datasets for all flood depth grids created. Follows the naming convention “DepthX”, where X = an integer return period between 2 – 500 years.
Elev	Folder	Contains raster datasets for all flood elevation grids created. Follows the naming convention “ElevX”, where X = an integer return period between 2 – 500 years.
Misc	Folder	Contains a raster datasets of upstream cross-section (when applicable)
FITResults	Personal geodatabase	All feature classes will be stored under “FITResults” feature dataset in the FITResults.mdb
Backlines	Polyline feature class	Indicates areas along the floodplain (buffer) boundary where flood depths exceed zero for the lowest frequency flood analyzed.
Backwater	Polygon feature class	Backwater polygons.
BoundaryX	Polygon feature class	Floodplain boundary for return period “X”.
Centerline	Polyline feature class	General centerline of flow.
EucXSecs	Polyline feature class	The set of flood elevation lines used in the depth grid analysis.
FloodPts	Point feature class	Flood elevation points used to interpolate the flood elevation grid(s).
Mask	Polygon feature class	Defines the analysis boundary.
Input	INI file	Project descriptive and analysis parameters.

## Coastal

Name	Type	Description
Depth	Folder	Contains raster datasets for all flood depth grids created. Follows the naming convention “DepthX”, where X = an integer return period between 10 – 500 years.
Elev	Folder	Contains raster datasets for all flood elevation grids created. Follows the naming convention “ElevX”, where X = an integer return period between 10 – 500 years. Also stores grids of shoreline segments, a sheet flow and hazard zone.
Misc	Folder	Contains raster datasets of shoreline segments, BFEs, and sheet flow depths.
Erosion	Folder	Contains raster datasets for erosion elevation and depth grids. Follows the naming convention “ErElevX” or “ErDepthX”, where X = an integer return period between 10 – 500 years.
Zone	Folder	Contains raster datasets for flood hazard zone. Follows the naming convention “ZoneX” where X = an integer return period between 10 – 500 years.
FITResults	Personal geodatabase	All feature classes will be stored under “FITResults” feature dataset in the FITResults.mdb
Shoreline	Polyline feature class	Generalized shoreline drawn by the user.
Transects	Polyline feature class	Shore normal transects used for frontal dune analyses.
BoundaryX	Polygon feature class	Floodplain boundary for return period “X”
Mask	Polygon feature class	Defines the Analysis Boundary
Erosion Pts	Point feature class	Eroded ground elevation points used to interpolate the eroded ground deviation grid.
Input	INI file	Project descriptive and analysis parameters.

## Appendix C – Troubleshooting Guide

### 1 Issue:



Cause: There are two potential causes and both are related to bugs in ArcMap:

- a. There is a file sharing error. The **FIT** is attempting to save a grid dataset, but another application (ArcCatalog or Windows Explorer) is claiming ownership or the grid has read-only permission.
- b. ArcMap will not allow a grid dataset to be overwritten because ArcMap erroneously believes there is an active map layer referencing the grid.

Solution:

- Note the file path to the grid dataset displayed in the error message.
- Save the ArcMap document and close ArcMap.
- If a grid dataset with the same name and path already exists, ensure the grid and associated information folder and contents have write permission.
- In Windows Explorer, ensure that the folder indicated in the error message is not open.
- In ArcCatalog, ensure that the folder indicated in the error message is not open.
- Open the Windows Task Manager and click on the Processes tab. Click on the “Image Name” field twice so that the application names are sorted in ascending order. If ArcMap.exe appears in the list, select it and click the “End Process” button.
- Open the ArcMap document and re-start the process that generated the error message.

C2

2 Issue: The **FIT** dialogs that allow drawing stay on top even when switching to other Windows applications.

Cause: There is an incompatibility between ArcMap and Visual Basic regarding modeless dialogs.

Solution: None. This is an ArcMap limitation.

3 Issue: After saving a new ArcMap document or using Save As to change the name of an existing document, the new name is not updated in the ArcMap title bar.

Cause: The **FIT** often uses the ArcMap title bar to post status messages. When not processing, the title bar will show the name of the current ArcMap document. But due to an ArcMap limitation, the title bar is not updated in certain circumstances.

Solution: Click on the ArcMap Save button.

4 Issue: A "Catastrophic Error" has occurred.

Cause: If an "Edit Session" is open when **FIT** is running, it will cause a conflict.

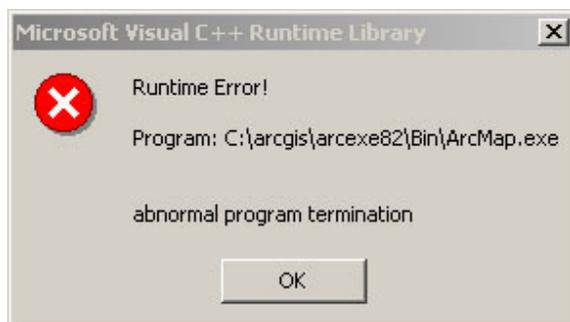
Solution: Close the "Edit Session" by selecting **Stop Editing** from the *ArcMap Editor* toolbar before running **FIT**.

5 Issue: Some of the layers disappear from view during a **FIT** analysis.

Cause: *ArcMap* is interrupted by clicking some button before it finishes refreshing.

Solution: Click the **Refresh View** button in *ArcMap*.

6 Issue:



Cause: There is a file sharing error. The **FIT** is attempting to save a grid dataset, but another application is claiming ownership or the grid has read-only permission.

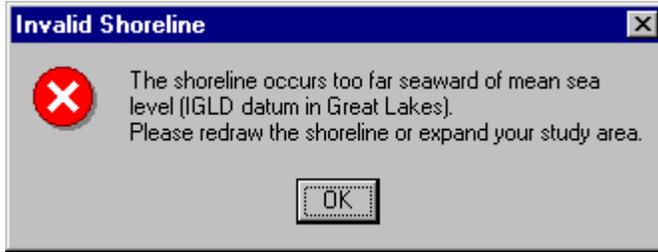
Solution:

- Close *ArcMap*.
- In Windows Explorer and *ArcCatalog*, ensure that no folders are open within the FIT working directory.
- Open the Windows Task Manager and click on the Processes tab. Click on the "Image Name" field twice so that the application names are sorted in ascending

order. If ArcMap.exe appears in the list, select it and click the “End Process” button.

- Open the *ArcMap* document and re-start the process that generated the error message.

7 Issue:



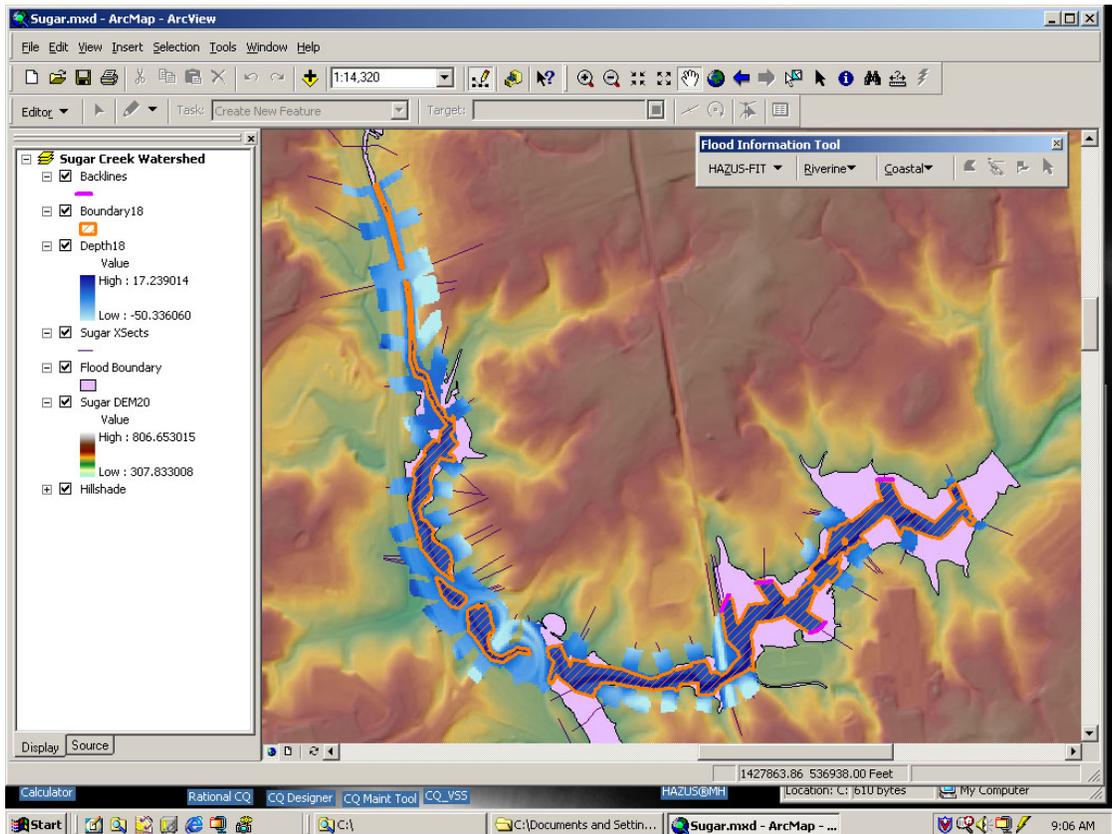
This message appears when the shoreline is definitely not seaward of mean sea level.

Cause: Bug with *ArcMap*'s identify tool.

Solution: Save and close *ArcMap*. Re-open *ArcMap* and continue with the Shoreline Wizard.

8 Issue:

The flood depth grid exists only along the stream centerline and cross-sections.



Cause: Unknown.

Solution: Re-run the Depth Grid Wizard.



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